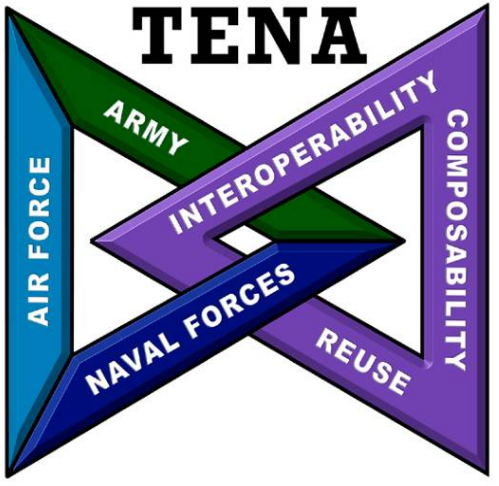
Test and Training Enabling Architecture (TENA) and the Joint Mission Environment Test Capability (JMETC)



Gene Hudgins

TENA and JMETC

User Support Lead

Agenda and Objectives

- **The TENA Architecture**
  - Architecture Structure
  - Architecture Details
    - Meta-Model
    - Object Model
    - Middleware
    - Repository and Utilities
- **JMETC**
  - JMETC Purpose
  - JMETC Accomplishments
  - JMETC Products
  - JMETC Plans
- **Summary and Conclusions**

- **Learning Objectives**
  - Benefits of TENA
  - The TENA approach to interoperability
  - The basic elements of TENA
  - The basic advantages of TENA
  - What to do to get more information on TENA
  - The new enterprise-wide approach to joint testing (JMETC)
  - JMETC's commitment to using TENA for its basic technical approach

Test Resource Management Center

"We are the stewards of the DoD test and evaluation (T&E) infrastructure"

VISION

"The Department of Defense T&E Ranges & Facilities will be fully capable of supporting the Department with quality products and services in a responsive and affordable manner"

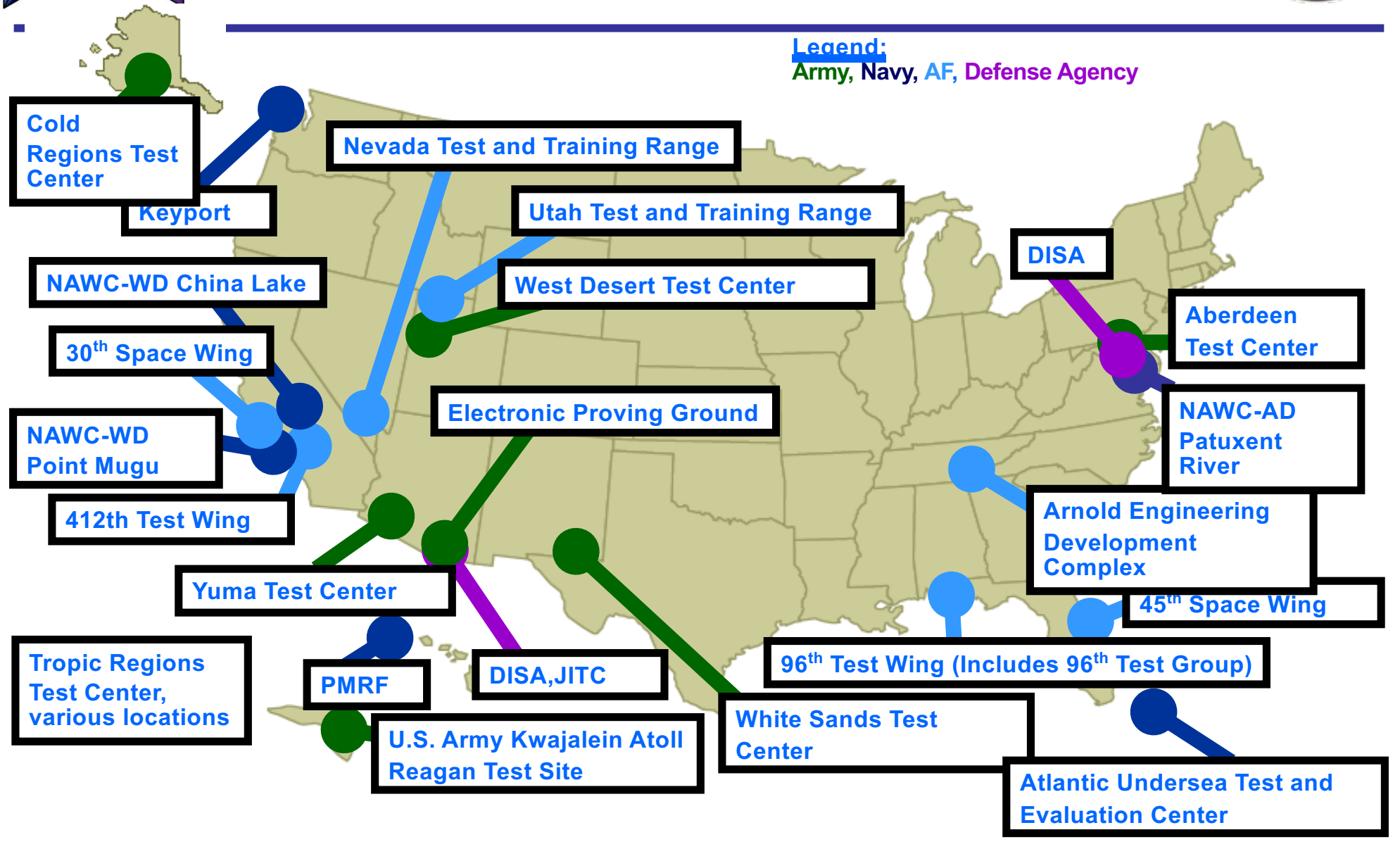
GOAL TO ACHIEVE THE VISION:

Robust and Flexible T&E Capabilities to Support the Warfighter

The STEWARD of the DoD Test Infrastructure

Major Range and Test Facility Base (MRTFB): The "Critical Core"

23 Sites: Army-8; Navy-6; Air Force-7; Defense Agency-2



Test Resource Management Center
Sec. 231, FY 2003 National Defense Authorization Act
DoD Directive 5105.71, March 8, 2004

- **DoD Field Activity**
- **Direct Report to USD(DT&E)**
- ★★★ **SES Director**

Oversee T&E Budgets
- MRTFB
- Other T&E Facilities Within & Outside DoD

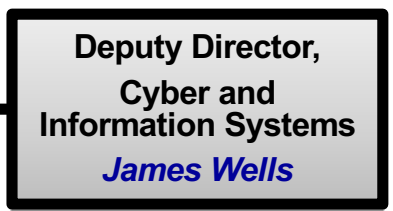
Biennial 10-Year Strategic Planning

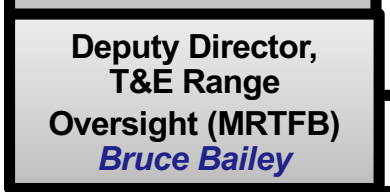
Annual T&E Budget Certification
Military Departments & Defense Agencies

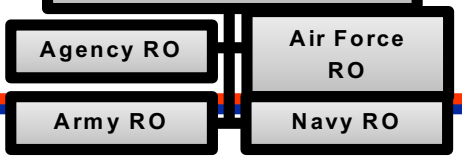
Administer T&E Investment Programs
(CTEIP, T&E/S&T & JMETC)

MRTFB Policy Oversight

DT&E / TRMC Combined Organization

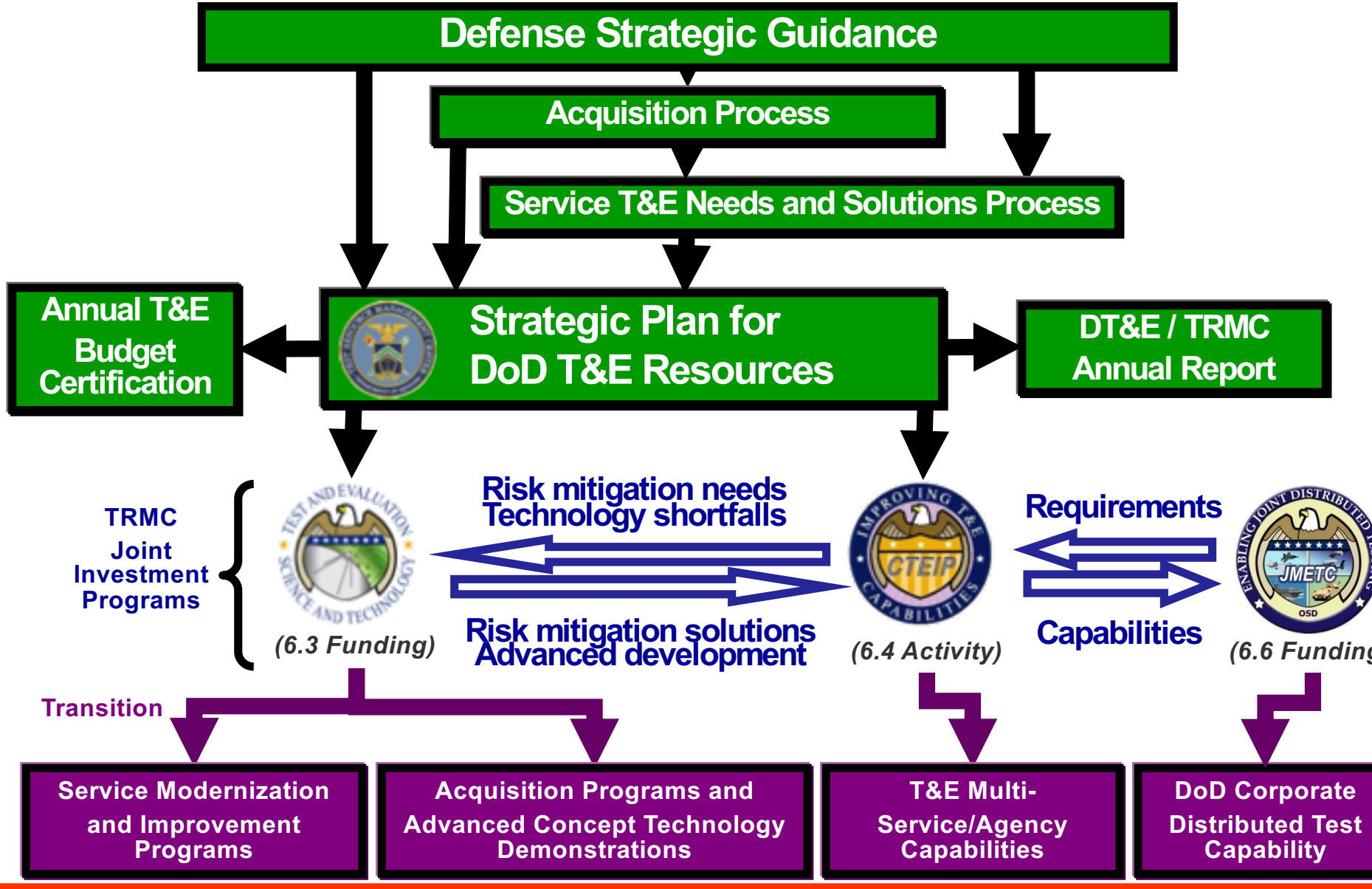






Updated 19 Nov 2015

The TRMC "Blueprint":
Putting Test Capabilities on the DoD Map



Test and Evaluation / Science and Technology (T&E/S&T) Program Overview

Mission: Develop Technologies Required to Test Future Warfighting Capabilities

- Established in FY02
  - Joint DDR&E / DOT&E Initiative
  - Transitioned to TRMC in FY05
- RDT&E Budget Activity 3 funds
- Purpose
  - High Risk / High Payoff R&D for Testing
  - Foster technology transition to major DoD test ranges
  - Risk reduction for test capabilities developments

70 Active Projects

- Annual Broad Agency Announcements (BAAs)
  - Academia
  - Industry
  - Government Laboratories
- Tri-Service working groups
  - Validate requirements
  - Evaluate proposals
  - Facilitate technology transition
- Central Oversight – Distributed Execution

Eight Test Technology Areas

High Speed Systems 18 Active Projects	Unmanned & Autonomous Systems 4 Active Projects	Spectrum Efficiencies 7 Active Projects	Advanced Instrumentation 14 Active Projects
Directed Energy 6 Active Projects	Cyberspace 2 Active Projects	Electronic Warfare 13 Active Projects	C4I & Software Intensive Systems 6 Active Projects

FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
$79.1M	$89.3M	$87.1M	$89.6M	$97.1M	$98.3M	$100.3M

Shaping Technology into Tomorrow's T&E Capabilities

CTEIP Overview

Mission: Develop or Improve Major Test Capabilities that have Multi-Service Utility

- Initiated DEPSECDEF – 9 November 1988
- Established in FY91 by Congress
- 6.4 RDT&E funds
- Purpose
  - Have multi-Service utility
  - Be developmental
  - Be non-procurement

43 Active Projects

T&E Master Plans (TEMP) References

Submarine Launched Countermeasure Emulator
- CBASS torpedo effectiveness testing against enemy countermeasure threats

MILSATCOM Atmospheric Scintillation Simulator
- AEHF survivability and effectiveness testing in realistic atmospheric environments

Ground Mounted Seeker Simulation
- Advanced open-air SAM simulator to support IDECM Block IV effectiveness testing

Threat Systems Simulator Development (TSSIM)

- 1-2 year requirement horizon
- EMD of target capabilities
- Address shortfalls in threat systems representation
- Coordinated with DOT&E

Joint Improvement & Modernization (JIM)

- 3-5 year requirement horizon
- EMD of Major Test Capabilities
- Must address joint requirements
- Services & Agencies budget for O&M over Life-Cycle of delivered capabilities

Resource Enhancement Project (REP)

- 1-2 year requirement horizon
- EMD of instrumentation needed to address an emergent requirement
- Must address OT shortfalls
- Coordinated with DOT&E

FY 11	FY 12	FY 13	FY 14	FY 15	FY 16
$162.3	$140.2	$151.5	$147.4	$147.9	$146.4

Notes: ($) in Millions: FY12 – PB Request

Central Test & Evaluation Investment Program (CTEIP)

Mission: Develop or Improve Major Test Capabilities that have multi-Service Utility

- **Established in FY91 by Congress with 6.4 RDT&E funds**

➢ Long-Term multi-Service Investments

Joint Improvement & Modernization (JIM)

JIM-Core

- 3-5 year requirement horizon
- EMD of major multi-Service test capabilities
- Development, not procurement
- Services & Agencies budget for O&M
- $110-120M/year, $550-$600M over 5 years

JIM-EW

- Special DoD area of emphasis
- EMD of electronic warfare (EW) test capabilities
- Assess aircraft performance against complex new threats.
- Service budget for O&M
- Total cost ~$465 over ~7 years

JIM-Hypersonics

- Special DoD area of emphasis
- EMD of hypersonic ground test capabilities
- Focus on hypersonic cruise & boost glide missiles
- Service budget for O&M
- Total cost ~$350 over ~5 years

➢ Near-Term Investments

Resource Enhancement Project (REP)

- 1-2 year horizon
- EMD of instrumentation to address near term OT shortfalls
- Coordinated with DOT&E
- $18-20M/year

Threat Systems Project (TSP)

- 1-2 year horizon
- Address shortfalls in threat systems representation
- Coordinated with DOT&E
- $3-5M/year

Requirements Drivers

Bi-annual multi-Service T&E Reliance Nomination Process	Multiple DoD EW studies	DoD Approved Roadmap	Annual review of OT shortfalls	Annual review of threat needs

21 JIM, 7 EW, 17 Hypersonics, 14 REP, 12 TSP = 71 Projects

Technology Readiness Levels

CTEIP

T&E/S&T Program

TRL 9	Actual system 'flight proven' through successful mission operations
TRL 8	Actual system completed and 'flight qualified' through test and demonstration
TRL 7	System prototype demonstration in an operational environment
TRL 6	System/subsystem model or prototype demonstration in a relevant environment
TRL 5	Component and/or breadboard validation in relevant environment
TRL 4	Component and/or breadboard validation in laboratory environment
TRL 3	Analytical and experimental critical function and/or characteristic proof of concept
TRL 2	Technology concept and/or application formulated
TRL 1	Basic principles observed and reported

Cost to Achieve

TRMC Investment Programs Overview

T&E/S&T

- Established in FY2002
- Develops technologies required to test future warfighting capabilities
- 6.3 RDT&E funds
- ~$95M / year
- 9 current Test Tech Areas
  - Directed Energy
  - High Speed Systems
  - Netcentric Systems
  - Cyberspace Test
  - Autonomous Systems
  - Advanced Instrumentation
  - Spectrum Efficiencies
  - Electronic Warfare

CTEIP

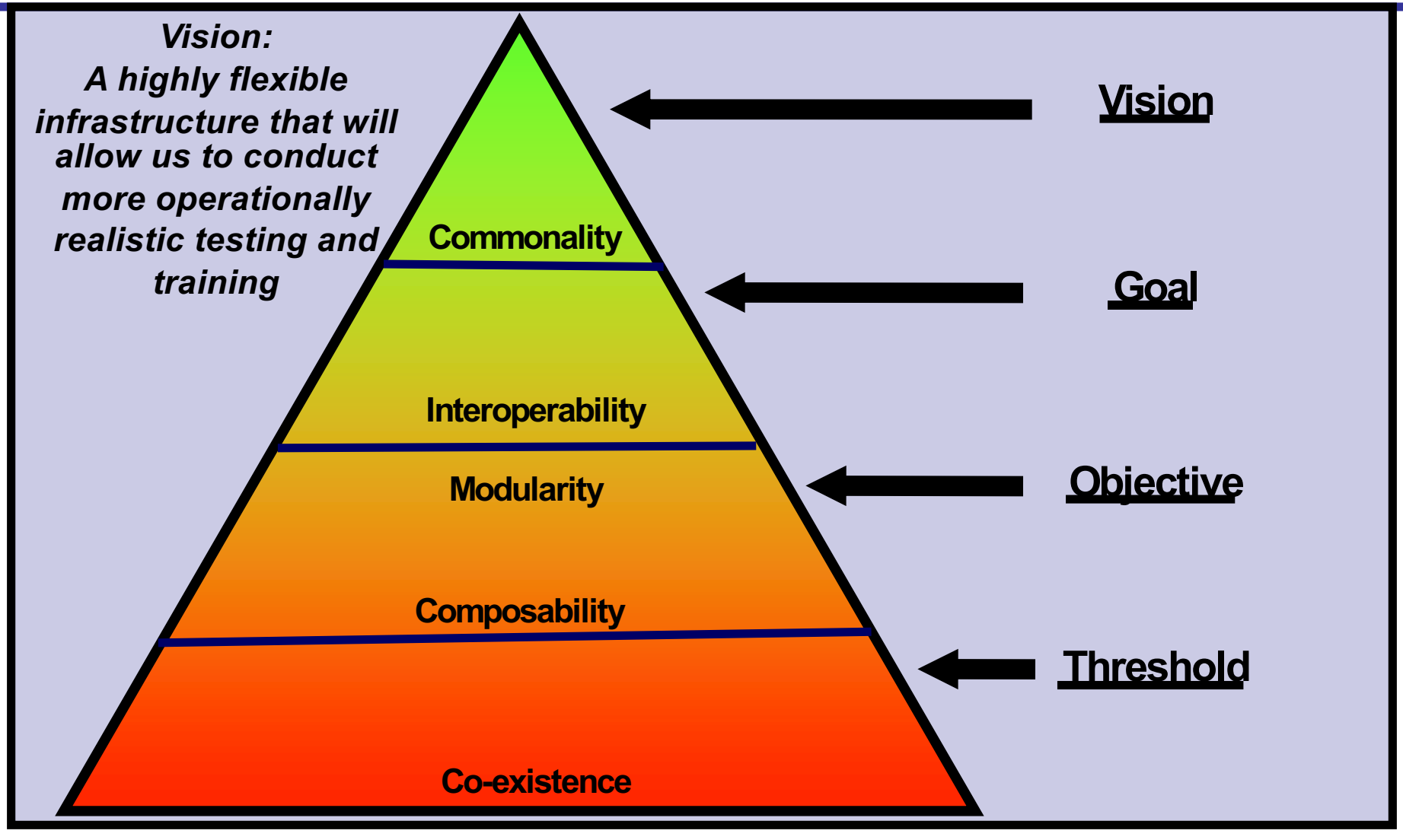
- Established in FY1991
- Develops or improves test capabilities that have multi-Service utility
- 6.4 RDT&E funds
- ~$140M / year
- 43 current projects
  - 19 projects developing core Joint capabilities
    - 4 projects improving interoperability test cap.
  - 11 projects improving threat representations used in testing
  - 13 projects addressing near-term OT shortfalls

JMETC

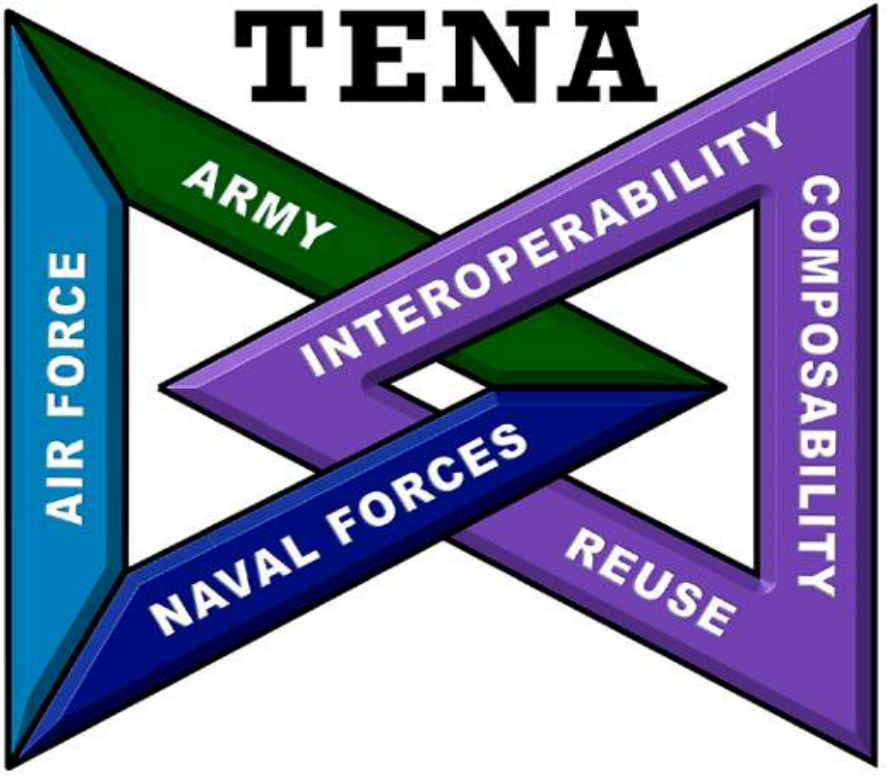
- Established in FY2007
- Provides corporate infrastructure for distributed Joint testing
- 6.5 RDT&E funds
- ~$19M / year
- 78 current sites
- Maintains
  - Network connections
  - Security agreements
  - Integration software
  - Interface definitions
  - Distributed test tools
  - Reuse repository

A TRMC Perspective:

Vision for a Common Test and Training Infrastructure



Test and Training Enabling Architecture



TENA Mission

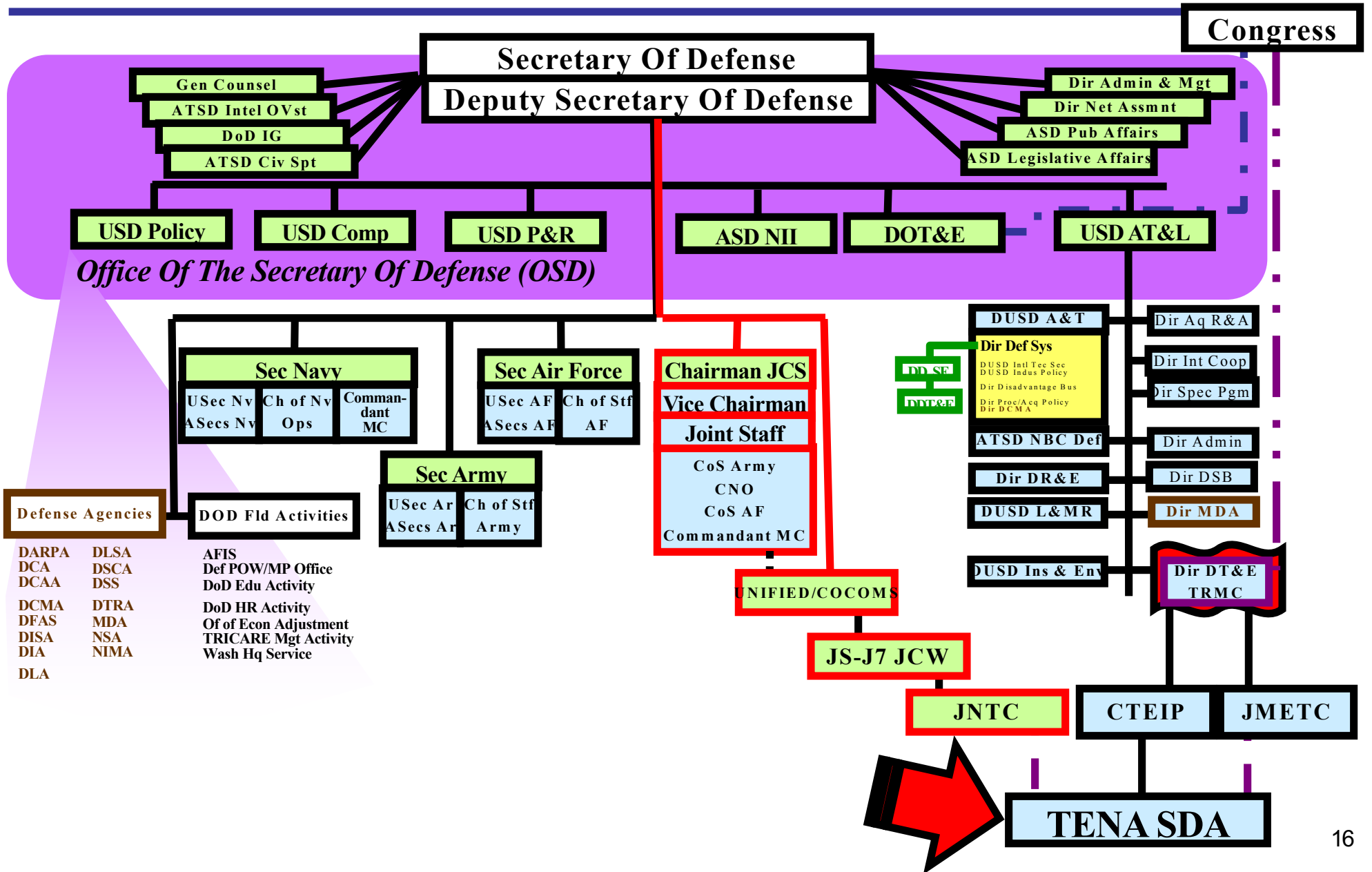
- Historically, range systems tend to be developed in isolation, focused on specific requirements, and constrained by aging techniques/technologies
- Range infrastructures have grown organically with minimal coordination or sharing, resulting in duplicated effort and many "stove-pipe" systems

The purpose of TENA is to provide the necessary enterprise-wide architecture and the common software infrastructure to:

- **Enable interoperability among range, C4ISR, and simulation systems used across ranges, HWIL facilities, and development laboratories**
- **Leverage range infrastructure investments across the DoD to keep pace with test and training range requirements**
- **Foster reuse of range assets and reduce cost of future developments**

Working with the Range Community to Build the Foundation for Future Test and Training Range Infrastructure

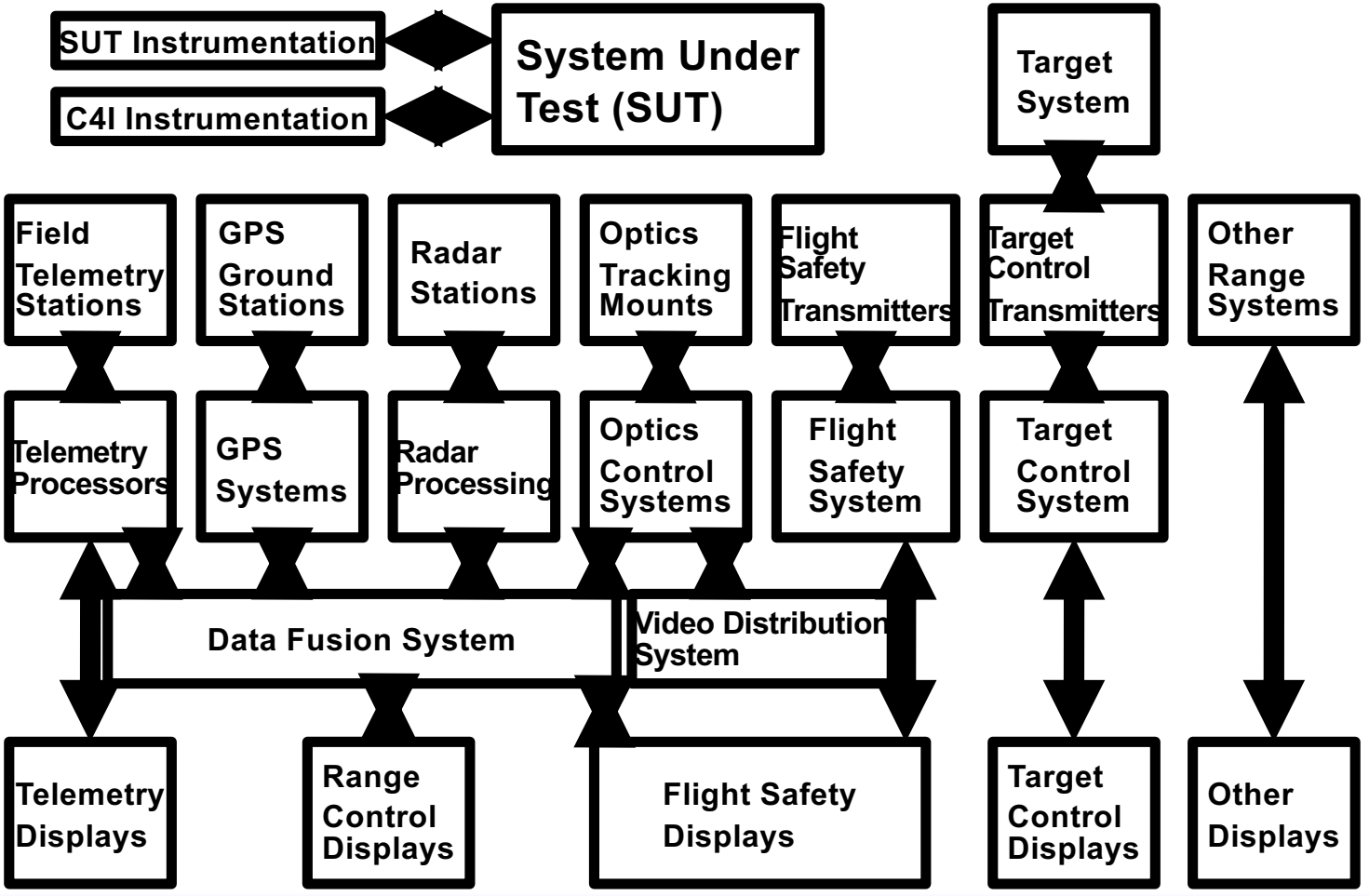
Where TENA SDA Fits in DoD



Benefits of TENA

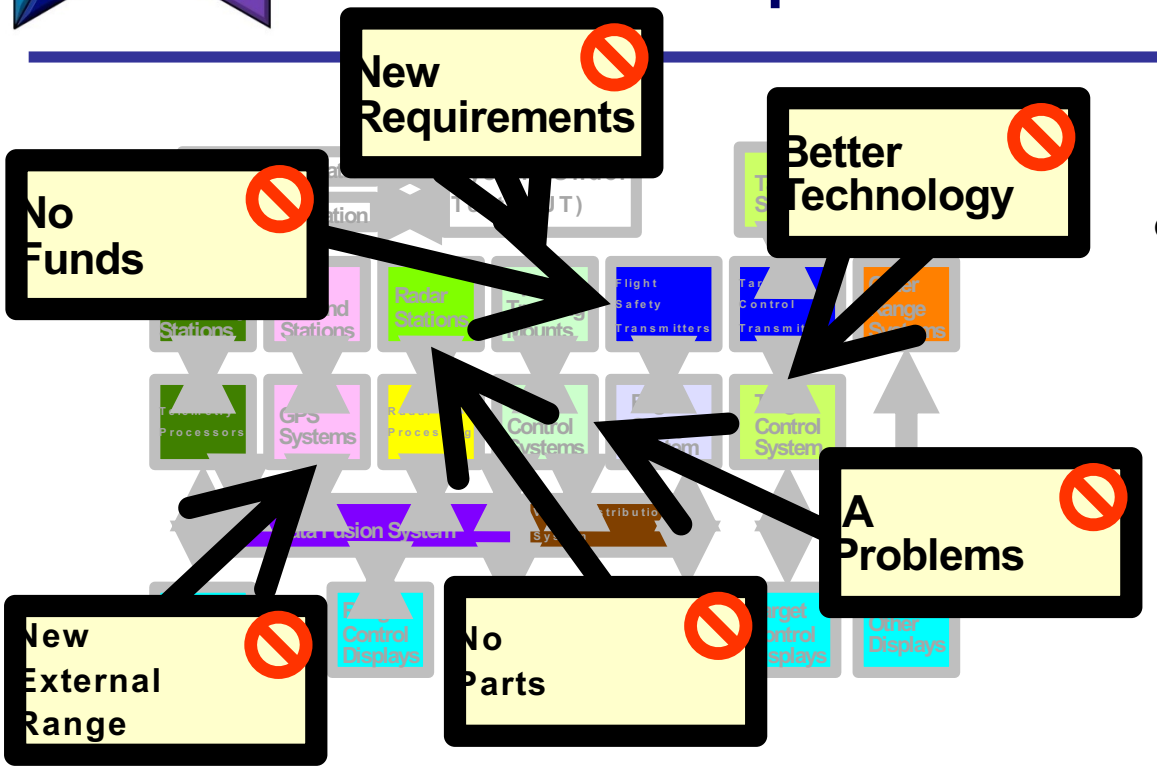
- **All TENA software and support is free to users**
- **TENA is the most capable and sophisticated interoperability solution**
- **TENA software is thoroughly tested and very reliable**
- **TENA Auto-Code Generation makes creating a TENA application as simple as possible**
  - TIDE Tool manages installation and configuration, upgrading and maintenance
  - Auto-generated starting points mean you never start with a blank page
  - **Rapid development** of real-time, distributed, LVC applications
  - Auto-generated test programs make integration a snap
- **TENA's technical approach emphasizes cost savings and reliability**
  - The TENA software is hard to use wrong
  - TENA catches many user errors at compile time rather than run time
  - TENA Tools provide unprecedented understanding of an event
- **TENA has a standard object model enhancing interoperability**
- **The TENA web site/repository has extensive documentation, training, and collaboration capabilities**
- **TENA has a plan for evolution and funding to execute this plan!**

A Notional Test Range



TENA is designed (and has experience) as the common communication infrastructure for these range systems

Range System and Infrastructure Development Challenges



- **General Development Challenges**
  - Multiple Developers and Development Groups
  - Different Timelines and Delivery Dates
  - New Computing and Communication Technologies

- **Range Specific Development Challenges**
  - Multiple Sponsors and Funding Sources
  - Evolving Test and Training Requirements
  - Expansion of Inter-Range Connectivity
  - Information Assurance Policies and Procedures
  - Range Modernization Must Be Gradual

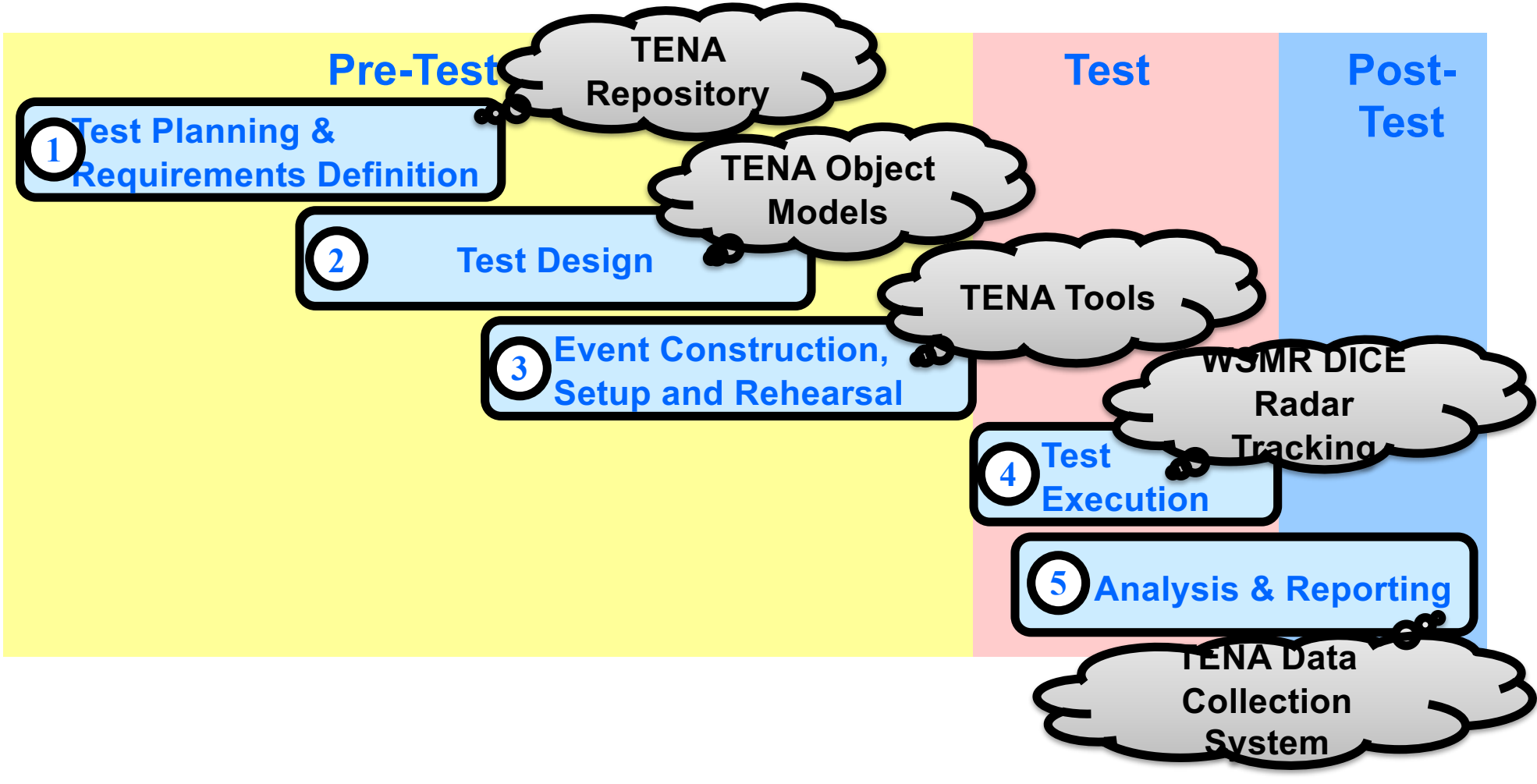
Test and Training Enabling Architecture (TENA) at a Glance

TENA is DoD's GOTS range integration architecture

- **What does TENA enable?**
  - Interoperability between inter- and intra-range assets
  - Elimination of proprietary interfaces to range instrumentation
  - Efficient incremental upgrades to test and training capabilities
  - Integration of Live, Virtual, and Constructive assets (locally or distributed)
  - Sharing and reuse of common capabilities across existing and new investments
- **What is included in the TENA architecture?**
  - Customizable "data contracts" that standardize repeatable information exchange
  - Interoperability-enabling, auto-code generated software libraries
  - A core set of tools that address common test and training requirements
  - Collaboration mechanisms that facilitate sharing and reuse
- **TENA has a plan for continued evolution and funding to execute this plan**

TENA ENABLED
Test and Training Enabling Architecture

Demonstration: Example Test Walkthrough

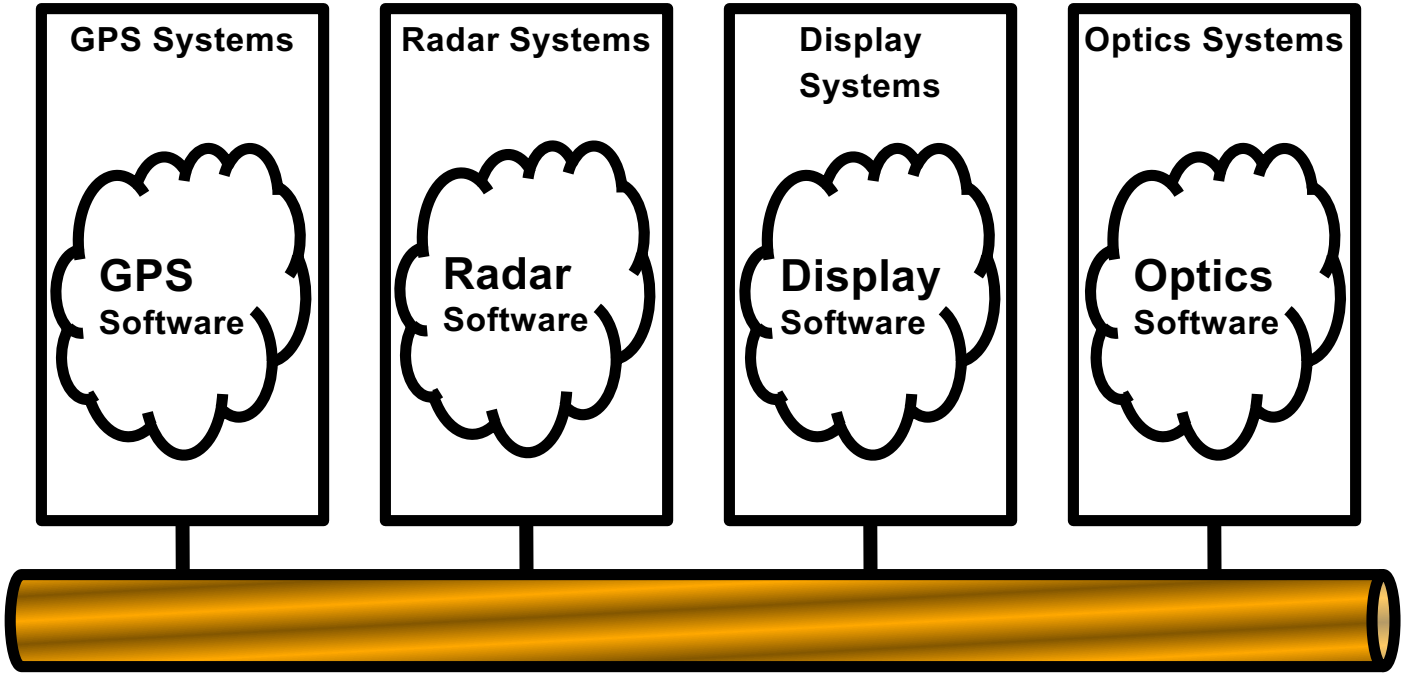


Previous Range Infrastructure Standardization Approaches

- **Standardize on computer/networking hardware**
  - Many ranges have been locked into particular computer vendors (e.g., SGI, Sun) or network technology (e.g., ATM, 2400 baud modem) that have constrained their ability to modernize systems efficiently
- **Standardize on programming language**
  - Many ranges have encountered problems with being able to maintain code developed with older programming languages and compilers
- **Standardize on the network protocol**
  - Many range protocols only support UDP broadcast or multicast, which can cause problems when connecting with external networks
- **Standardize on the message format**
  - Many message protocols emphasize the specific bit layout of message formats which prevents evolution for newer technology and requirements

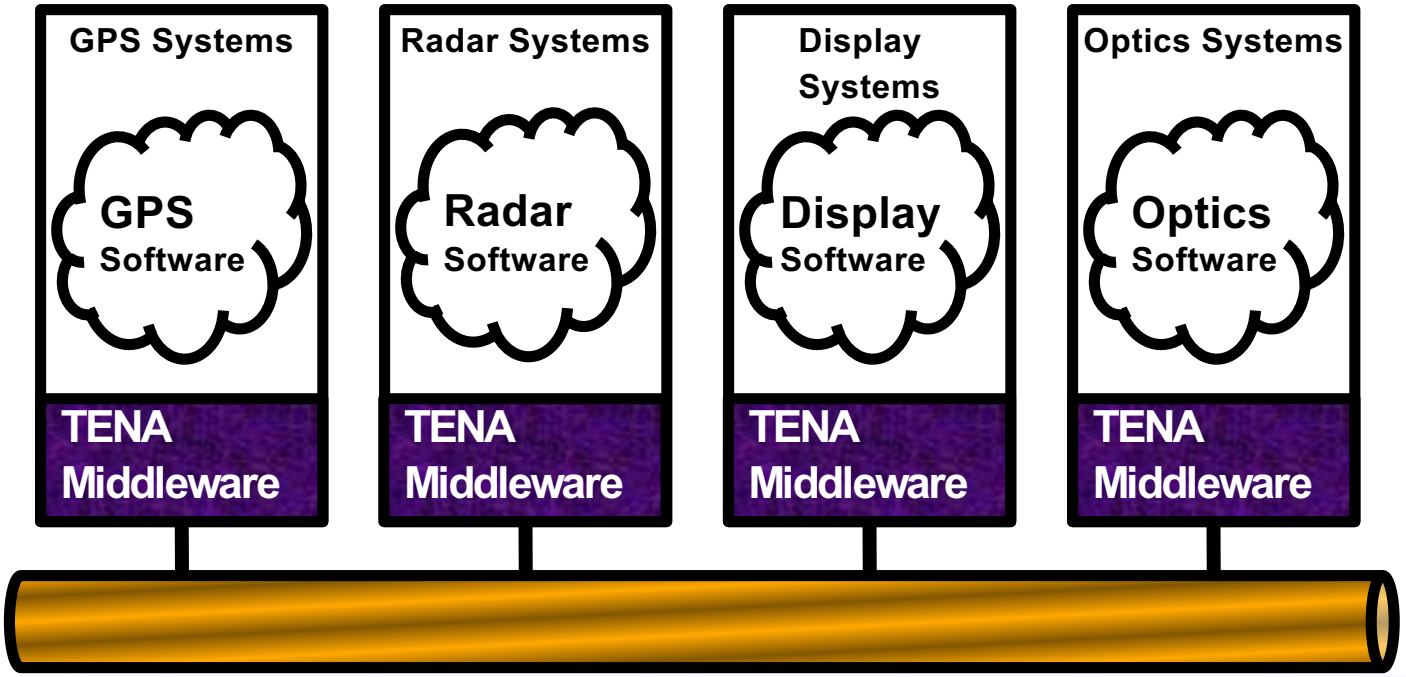
Systems get designed around elements that are difficult to upgrade often resulting in a fragile collection of gateways and brittle systems

Anatomy of Range Systems



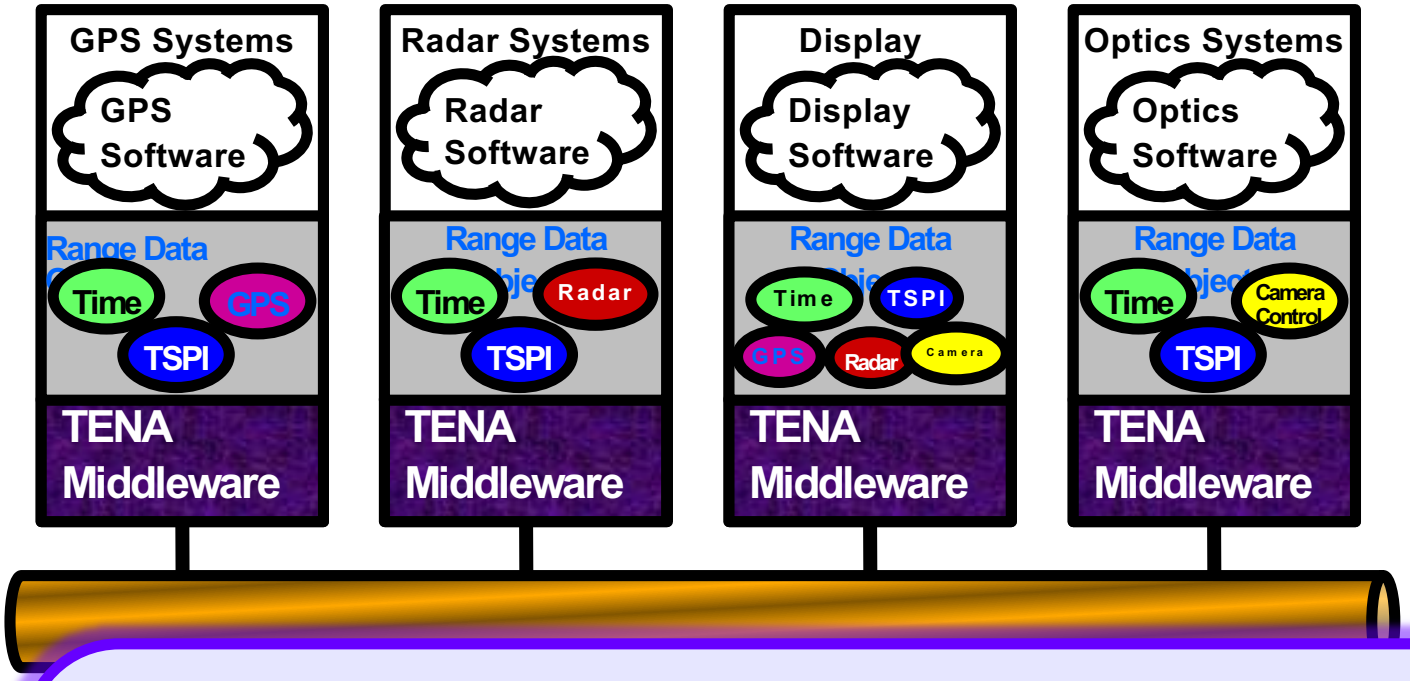
- **Traditionally, all developers must develop (often independently at different times) code that performs the function of data exchange between systems**
  - **Data preparation, packet marshalling/demarshalling, network communication, error handling, etc.**

TENA Middleware
(Software Library of Data Exchange Functions)



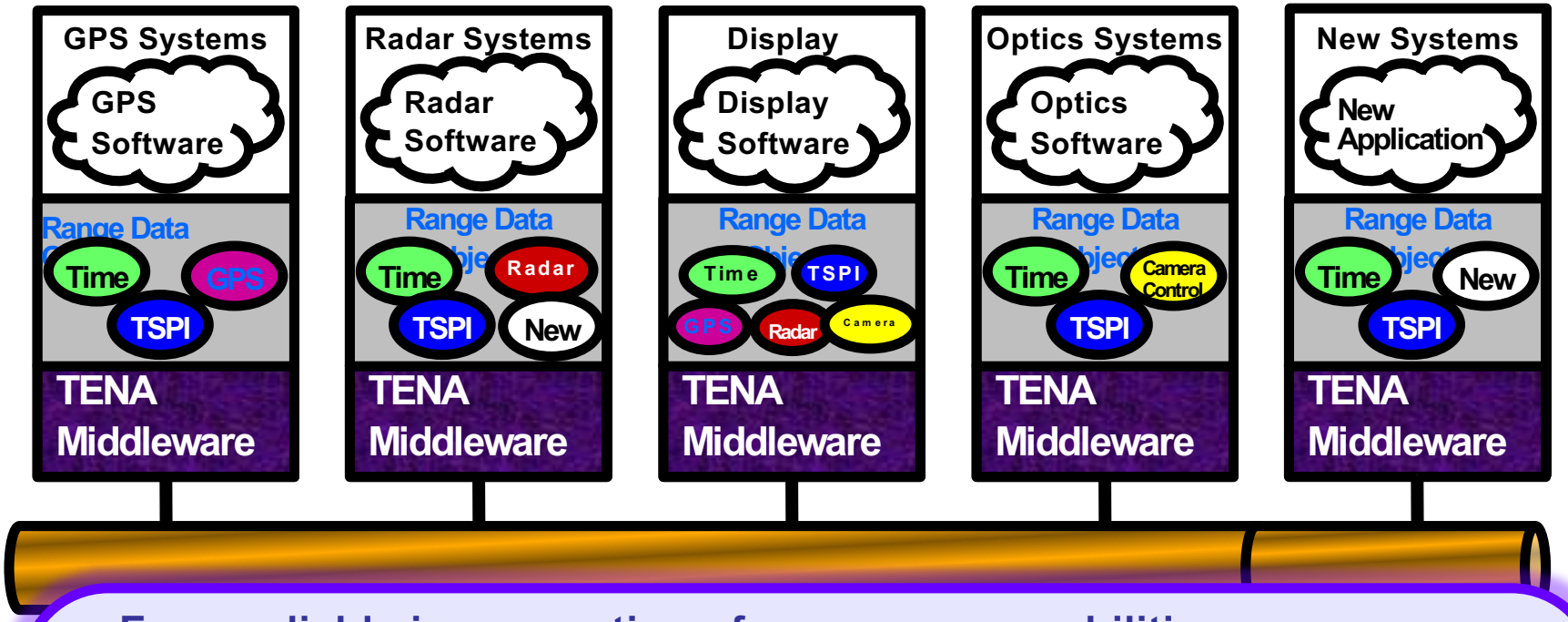
- **TENA Middleware is a set of software that performs real-time data exchange between systems**
  - Support for C++, Java, and .NET programming languages
- **TENA Middleware available for ~40 platforms, including:**
  - Windows XP, Vista, 7/8, Server 2008/2012 (32- and 64-bit)
  - Linux: Fedora 12/14/16/19, Red Hat 4/5/6, CentoOS 6, SUSE (32- and 64-bit)
  - Embedded Devices: Overo Gumstix (beta release)

TENA Object Models
(Range Data Formats & Algorithms)



- TENA Object Models are auto-code generated software interfaces that include data formats, data definitions, and common algorithms
- Auto-coded interface software can be standard TENA Object Models that the community has designed and agreed upon, or they can be designed for unique user requirements
- Standard TENA Object Models already developed include:
  - Time, TSPI, Coordinate Systems (including conversions), GPS, Radar, Telemetry, Event Control, Video Distribution, Weather

Adding New Range Capabilities

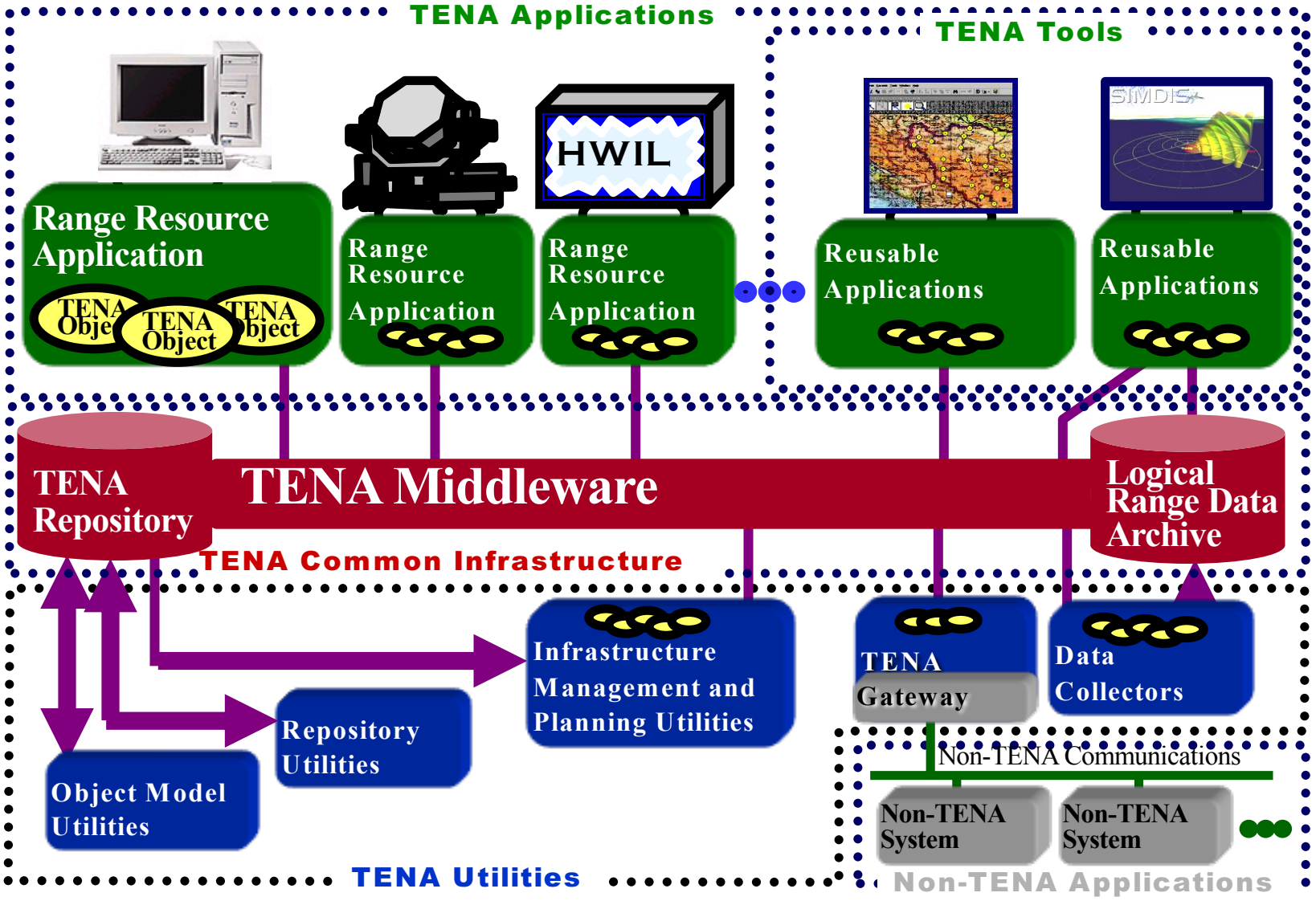


- Easy, reliable incorporation of new range capabilities
  - Known data exchange software (TENA Middleware)
  - Reuse standard range objects (Standard TENA Object Models)
    - Auto-code generate any new object models
  - Range interface on new application verified while application is developed (verification performed during software compile)
  - TENA Middleware verifies new application is using the same formats & algorithms when the application is started

Core Architectural Tenets of TENA

- **Promote Computer Enforceable System Interfaces**
  - For meaningful interoperability, systems should formally define their interfaces for the particular data produced or consumed and the services/algorithms provided or required
  - Generic interfaces may look appealing, but significant costs exist with performance, interoperability, and maintenance that are overlooked with this perceived flexibility
- **Utilize Auto-Code Generation to Raise the Abstraction Level**
  - Distributed programming is hard! Define higher level abstractions to automatically generate properly designed and tested source code for common distributed programming solutions—similar to comparison of modern programming languages to assembly code
- **Let Computer Detect Interoperability Errors as Early as Possible**
  - When would you like to detect interoperability problems? Many system errors can be detected by the computer during the development phase, reducing overall expense
- **Design the Middleware to Make it Hard to Use Wrong**
  - TENA Middleware is defined from a defensive posture that minimizes the opportunity for improper usage and run-time anomalies
- **Anticipate Better Techniques and Technologies**
  - Maintain separation between interfaces and implementations to simplify transition to improved techniques and technologies when appropriate

TENA Architecture Overview



The Ways in Which TENA Applications Can Communicate

TENA provides to the application developer a unification of several powerful inter-application communication paradigms:

- **Publish/Subscribe**
  - Each application publishes certain types of information to which any other application can subscribe
  - Similar in effect to HLA, DIS, CORBA Event Service, DDS, etc.
- **Remote Method Invocation (RMI)**
  - Each object that is published may have methods that can be remotely invoked by other applications
  - Similar to CORBA RMI or Java RMI
- **Distributed Shared Memory (DSM)**
  - Applications read and write the state of objects as if they were local objects, even though they are remote objects
  - A very natural, easy to understand programming paradigm that projects the illusion of working on a shared memory multi-processor machine onto a distributed computing system
- **Messages**
  - Individual messages that can be sent from one application to other applications

How do we use TENA for a particular system?

1. **Determine the "ins and outs" of the Particular System**
   - Any system that needs to interoperate with other systems needs to define the data and services shared with these other systems—TENA defines these "ins and outs" as formal data contracts that are easily understood by humans and enforced by computers
   - Determine if existing interfaces (called object models) already exist—TENA Repository has over 1,200 object models that have already been defined by the user community
2. **Auto-Generate Application Source Code**
   - TENA Repository will automatically generate source code for a tested and working example application based on the user's particular object models—developers just need to replace the "dummy" behavior for setting/getting attribute values and implementing methods
3. **Integrate Generated Code into Existing System**
   - Working example code simplifies ability to insert the TENA specific code into an existing system, or the example code can be used as the basis for developing a new system
4. **Connect System to Network to begin Collaborating with Others Systems**
   - Publish-Subscribe paradigm makes it easy (no event specific configuration) for multiple participants to share data and services, as well as providing support for redundancy and evolution to new systems

TENA's auto-code generation capability creates tested and proven user specific example applications in minutes!

How hard is it to create a new TENA Object Model?

1. Name the object model, including the version
2. Define the message or object types needed by the application
3. Define the attributes that characterize the messages and objects
4. Determine if any attributes are constant or optional
5. Define any remote or local methods

```
file Example-Vehicle-v6.tdl

package Example {

  enum Team {
    Team_Red,
    Team_Blue,
    Team_Green };


  class Vehicle {

    optional string name;
    Team team;
    const float64 xInMeters;
    float64 yInMeters;


  };driveTo (float64 xInMeters,
             float64 yInMeters);


};
```

TENA has a powerful meta-model for defining expressive object models, yet descriptive models are easy to create

How do we integrate TENA into our existing environment?

- **Gradual Deployment**
  - TENA can be introduced into an existing environment in a gradual manner in which certain systems are replicated using TENA functionality
  - These initial systems will typically require temporary gateways to bridge between TENA and the legacy protocol and systems
- **Gateway with Legacy Protocol and Systems**
  - TENA gateway systems are well understood, and a separate project, PRITEC, has even created a Gateway Builder product to facilitate automated gateway creation
  - Migration to TENA can be coordinated with respect to publishing/subscribing characteristics to minimize any performance degradation caused by the gateway
- **Utilize Redundancy during Testing**
  - Access to both the legacy and the upgraded TENA system provides system redundancy during initial testing and operational deployment to minimize risk

TENA can be introduced to a range gradually using a properly designed protocol gateway system

Will TENA meet my performance requirements?

- **Users are encouraged to conduct experiments by customizing the auto-generated example programs to be representative of actual systems**
  - Use actual object models, computers, and networks
- **Primary requirement for TENA is to support high performance, real-time distributed communication**
  - TENA uses compiled code to avoid interpretive marshalling/demarshalling
  - Minimizes data copies, utilize single thread to perform network write, etc.
- **Representative TENA Middleware Performance**
  - RRRP RadarTrack updates (~10 year old laptops running Fedora 12)
    - **Update Throughput: 6,700 updates/second**
    - **Update Latency: 0.50 milliseconds**

There is some overhead associated with TENA, versus a highly customized communication infrastructure, but those "one-off" solutions are expensive to maintain and are, ultimately, very limiting

Why do some find TENA to be intimidating at first?

- **TENA has a lot to offer**
  - Requirement studies for a common T&E range infrastructure began in the mid-1990's, with the first middleware release in Oct. 2001
  - All of the TENA features and improvements are a direct result of the practical experience of our users who have made more than 10,000 separate middleware downloads since 2005
- **TENA uses framework software patterns and strong type safety to improve the quality of all user applications**
  - These software techniques enforce certain constraints that may initially seem foreign to some developers, but they enable our community to determine most effective ways to provide common infrastructure solutions

Developing and maintaining range systems is a challenging endeavor, but there is an enormous (and growing) amount of practical range experience embodied in TENA

TENA is an Open Architecture

- **The Software Engineering Institute defines an Open System as "a collection of interacting software, hardware, and human components designed to satisfy stated needs with interface specifications of its components that are fully defined, available to the public, maintained according to group consensus, in which the implementations of the components conform to the interface specifications."**
- **TENA is maintained according to a consensus of its users assembled as the TENA Architecture Management Team (AMT)**
- **TENA Middleware exists and is being used to support real events**
  - Government owned, without proprietary software
- **TENA is freely releasable (Distribution A) to non-US entities**
  - We have many non-US users in Britain, France, Sweden, Denmark, etc.
- **Currently there are no plans for standardizing TENA in the same way as DIS and HLA have been standardized (IEEE)**
  - However, we are looking into innovative mechanisms to get the same usability and confidence with TENA as we do with open standards
  - TENA's business model is not the same as the DIS and HLA business models

Architecture Management Team (TENA AMT)

- **Current AMT Members:**
  - 329 Armament Systems Group (329 ARSG)
  - Aberdeen Test Center (ATC), Aberdeen Proving Ground, MD
  - Air Armament Center (AAC), Eglin AFB, FL
  - Air Force Flight Test Center (AFFTC), Edwards AFB, CA
  - Alaska Training Range Evolution Plan (ATREP)
  - Army Operational Test Command (OTC), Fort Hood, TX
  - Common Training Instrumentation Architecture (CTIA)
  - Common Range Integrated Instrumentation System (CRIIS)
  - Dugway Proving Ground (DPG)
  - Electronic Proving Ground (EPG)
  - integrated Network Enhanced Telemetry (iNET)
  - Interoperability Test and Evaluation Capability (InterTEC)
  - Joint Fires Integration & Interoperability Team (JFIIT)
  - Joint Mission Environment Test Capability (JMETC)
  - Joint National Training Capability (JNTC)
  - Naval Air Warfare Center – Aircraft Division
  - NAWC – Weapons Division
  - Naval Aviation Training Systems Program Office (PMA-205)
  - Naval Undersea Warfare Center (NUWC)
  - NAVSEA Warfare Center - Keyport
  - P5 Combat Training System (P5CTS)
  - Pacific Missile Range Facility (PMRF)
  - Redstone Test Center (RTC)
  - T&E/S&T Non-Intrusive & Advanced Instrumentation
  - White Sands Missile Range (WSMR)
  - Yuma Proving Ground (YPG)

Industry Advising Members

- **Boeing**
- **Cubic Defense**
- **DRS**
- **Embedded Planet**
- **EMC**
- **General Dynamics – C4 Systems**
- **Kenetics**
- **MAK Technologies**
- **NetAcquire**
- **Raytheon**
- **Science Applications International Corp (SAIC)**
- **Scientific Research Corporation (SRC)**
- **Scientific Solutions, Inc. (SSI)**
- **Trusted Computer Solutions**

International Participation

- **Australia**
- **Denmark**
- **France**
- **Singapore**
- **Sweden**
- **United Kingdom**

- **Design Decisions / Trade-offs / Status / Technical Exchanges of Lessons Learned / Use Cases / Testing / Issues & Concerns Identification, Investigation & Resolution**

TENA Information Assurance (IA) Activities

- **Air Force Evaluated/Approved Product List (E/APL)**
  - Software Certification for TENA Middleware Version 6.x
- **Navy Application & Database Management System (DADMS)**
  - Approved 6/27/2011
- **Army Certificate of Networthiness (CoN)**
  - Covers TENA Middleware, TENA Utilities, and TENA-enabled applications
- **S/DREN (Secret/Defense Research and Engineering Network)**
  - TENA protocol and TENA-based applications approved for DREN and SDREN sites
- **NIPRnet**
  - JTTOCC (which includes TENA Middleware) obtained ATO on NIPRnet
- **Air Force 46th Test Wing DIACAP**
  - InterTEC tool suite (includes TENA Middleware) completed DIACAP testing, ATO submission in process
- **DoD PPSMO Category Assurance List (CAL)**
  - Conditional approval for TENA use on classified and unclassified network enclave, awaiting final approval
- **Unified Cross Domain Management Office (UCDMO)**
  - TENA-enabled Cross Domain trusted guard SimShield v2.2.0.1 on baseline list
- **Joint RDT&E Reciprocity Overlay Team (JRROT)**
  - Foundational set of controls for basing reciprocity determinations for RDT&E

TENA project works with IA organizations to reduce cost and delays to improve IA considerations with TENA applications

Some Examples of TENA Usage

- InterTEC (C4ISR stim/sim/collection)
- JDAS (data archive)
- TVDS (video distribution)
- JMITS (live range IR threat emulator)
- SIMDIS (range display)
- Starship (event control)
- Gateways (translators to DIS & HLA)
- CTIA (training instrumentation)
- ARDS (precision TSPI)
- CRIIS (next generation precision TSPI)
- P5 (precision TSPI / ACMI)
- NACTS (precision TSPI / ACMI)
- SimShield (trusted data guard)
- Reflect (data playback)
- MatLab (data analysis)
- Execution Manager GUI (event control)
- IVT (interface/network verification tools)
- JAAR (after action review)
- JIMM (constructive simulation)
- JSAF (constructive simulation)
- DCIT (distributed monitoring)
- Link-16 translator (Link-16 over WAN)
- PET (air picture data analysis system)
- JWinWAM (test assessment tool)
- Real-time Casualty Assessment System
- ICADS (individual combat aircrew dis. sys.)
- ATREP (training instrumentation)
- iNET (wireless networking)
- CRS-P (constructive simulation)
- AEA HWIL (airborne electr. attack lab)
- OT-TES (tactical engagement sys for OT)
- ADMAS (embedded vehicle instruments)
- HWIL RF threat injection system
- Radars (tracking, surveillance, miss-distance)
- Range optics (high fidelity remote control)
- Threat systems
- UAV remote control of sensors
- Range safety systems
- Embedded instrumentation
- Weather server (distribution of weather data)
- Player ID server (Unique ID for entities)
- Open air range acoustic sensors
- Undersea hydrophone instrumentation
- Live video – synthetic scene integration

Partial Listing of Recent Testing, Training, and Experiments Using TENA-Compliant Capabilities

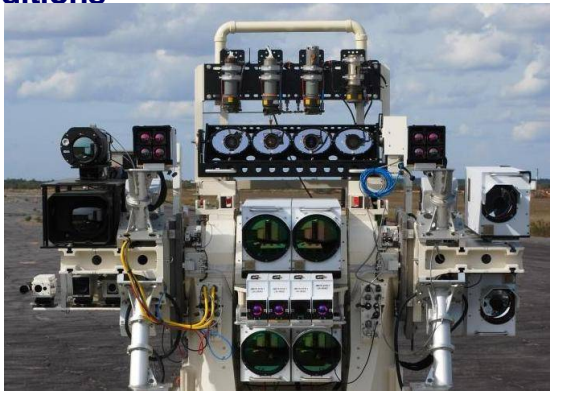
- *Test Events*
  - Joint Distributed IRCM Ground-test System (JDIGS), Mar 10-Ongoing
  - Interoperability Test and Evaluation Capability (InterTEC) Cyberspace Event, Nov 11
  - Air-to-Ground Integrated Layer Exploration (AGILE) Fire III, IV, V, Jan-Nov 11
  - Joint Track Manager Concept-Demonstration (JTMC-D), Jun-Sep 11
  - Joint Integration Air & Missile Defense Office (JIAMDO) Joint Sensor Integration (JSI), Apr-Aug 11
  - Air Force Systems Interoperability Test (AFSIT), Jun-Jul 11
  - Joint Strike Fighter (JSF) Test, Jun 11
  - JIAMDO Correlation / Decorrelation Interoperability Test (CDIT) United Kingdom, Oct 10, Mar 11
  - JIAMDO CDIT CONUS, Sep 10-Jan 11
  - JITC Joint Interoperability Test (JIT) of Air Defense Systems, Sep-Nov 10
  - Broad Aerial Maritime Surveillance (BAMS) Test Oct 09 and Oct 10
  - Battlefield Airborne Communications Node (BACN) Joint Urgent Operational Need (JUON), Aug 10
  - B-1B Link-16 Interoperability Testing, Mar-Apr 10
  - Joint Electronic Warfare Assessment for Test and Evaluation, Sep 09

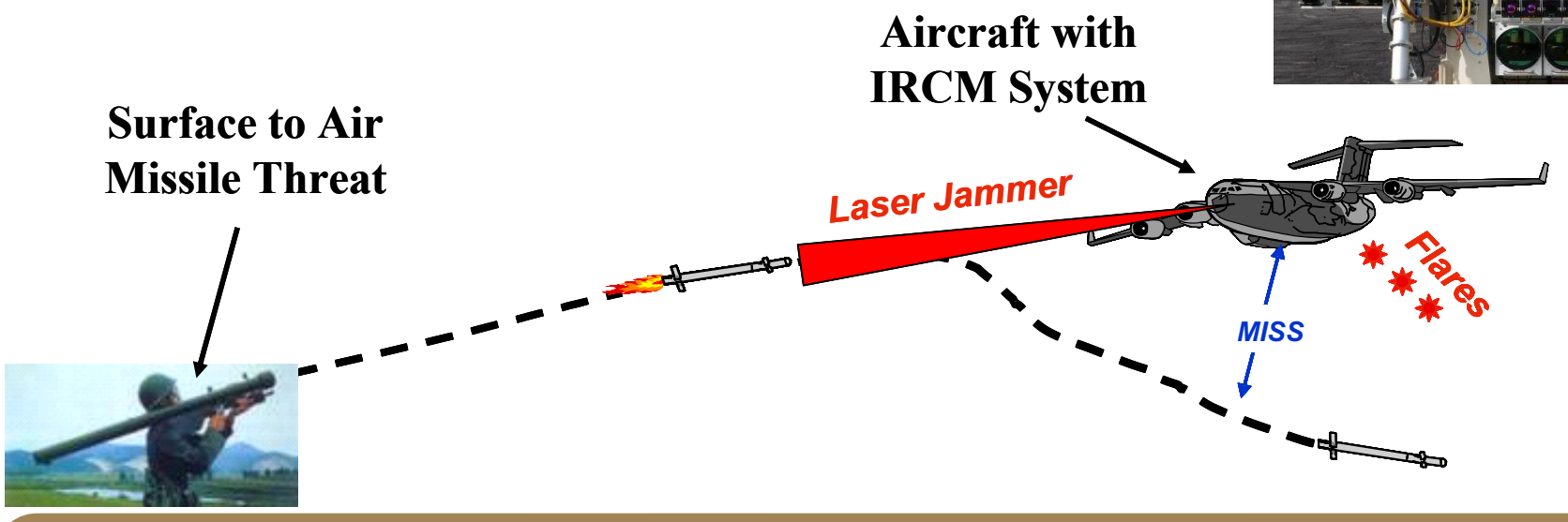
- *Training Exercises*
  - Daily Training, Eielson AFB
  - Daily Training, Fallon AFB
  - Unified Endeavor (UE) 11-3, May-June 11, UE 11-1 Phase 6, Aug-Sep 11
  - Joint Close Air Support (JCAS) Distributed Test, Jun 10
  - Red Flag Alaska (RFA), four times a year since 2008, Pacific Alaska Range Complex (PARC)
  - JDEWR Cope Tiger 09, Mar 09, PARC
  - RFA 09-2, April-May 09, PARC
  - Distant Frontier, May-Jun 09, PARC
  - Northern Edge 09, Jun 09, PARC
  - Talisman Sabre 09 - Australian Army and US Army, Jul 09, Shoalwater Bay, Queensland Australia
  - RFA 09-3, Jul-Aug 09, PARC
  - JDEWR Talisman Sabre 09, Jul 09, PARC
  - RFA 10-1, Oct 09; 10-2, Apr 10; 10-3 Aug 10
  - Northern Edge, Jun 10

- *Experiments*
  - Joint Surface Warfare (JSuW) Joint Capabilities Technology Demonstration (JCTD), Oct 10
  - Joint Expeditionary Force Experiment (JEFX) 09-1, 09-2, 09-3, Feb-Apr 09
  - JEFX 09-4 B-2 Test (Spirit ICE), Aug 09
  - JEFX 10-1, 10-2, 10-3, Jan-Apr 10

Joint Mobile IRCM Test System (JMITS) and Multi-Spectral Sea and Land Target Simulator (MSALTS)

- **Illuminates IRCM sensors with UV and IR plume radiation of approaching missiles**
  - **Wide variety of threat missile types, engagement geometries, and weather conditions**
- **Measures countermeasure response**
  - **Flares (captive seekers)**
  - **Laser jammer (jam beam radiometers)**
- **Both Systems have deployed TENA for all Internal and External Communication**



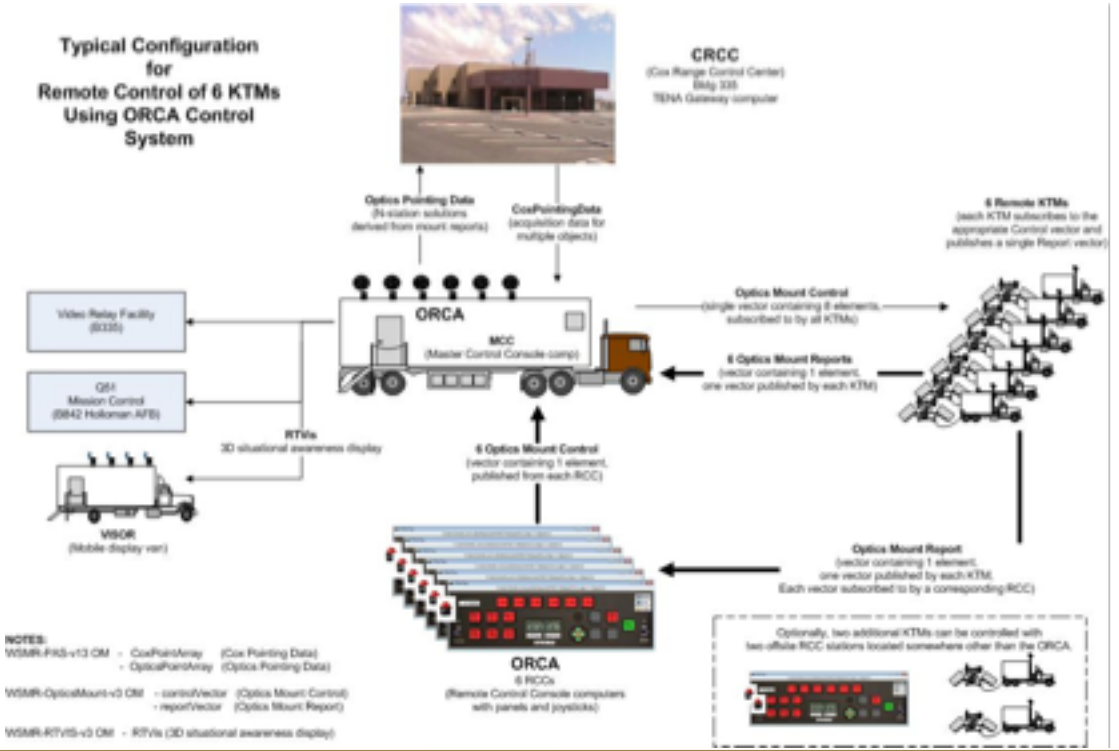


The MSALTS internal architecture attains a high degree of flexibility because of the modularity TENA offers. TENA makes sharing reliable state data between services simple.

Tyson Horrocks
MSALTS Lead Software Engineer

TENA at White Sands Missile Range (WSMR)

- **TENA has been supporting the real-time distributed operation of the WSMR optics systems for the past 10 years, including data exchange and remote operation**
  - **Based on the success of optics, TENA is being expanded to other range systems**



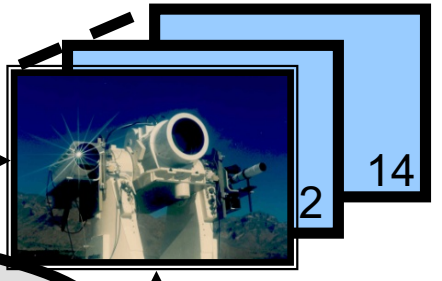
"TENA has functioned extremely well in our network environment and the rigorous requirement of 60 Hz updates to the instrumentation."

Charlie Conroy
WSMR Optics Development Engineering Lead

A Compelling, Comprehensive Range Instrumentation Use Case at White Sands

20 Hz

60 Hz



Optics Multi-cast Group

Test Support Network
TSN / IP

DREN

IRCC

MRTFB 2

MRTFB 3

Measureand Object on **TENA V6**

TM Multicast Group

Telemetry Pre-Processor

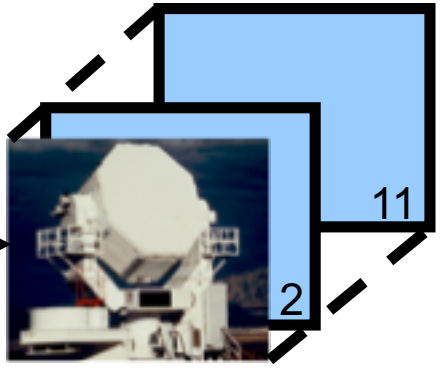
Radar Track Object on **TENA V6**

Radar Multicast Group

Cox Pointing Data Object on **TENA V6**

NetAcquire

on TENA V6

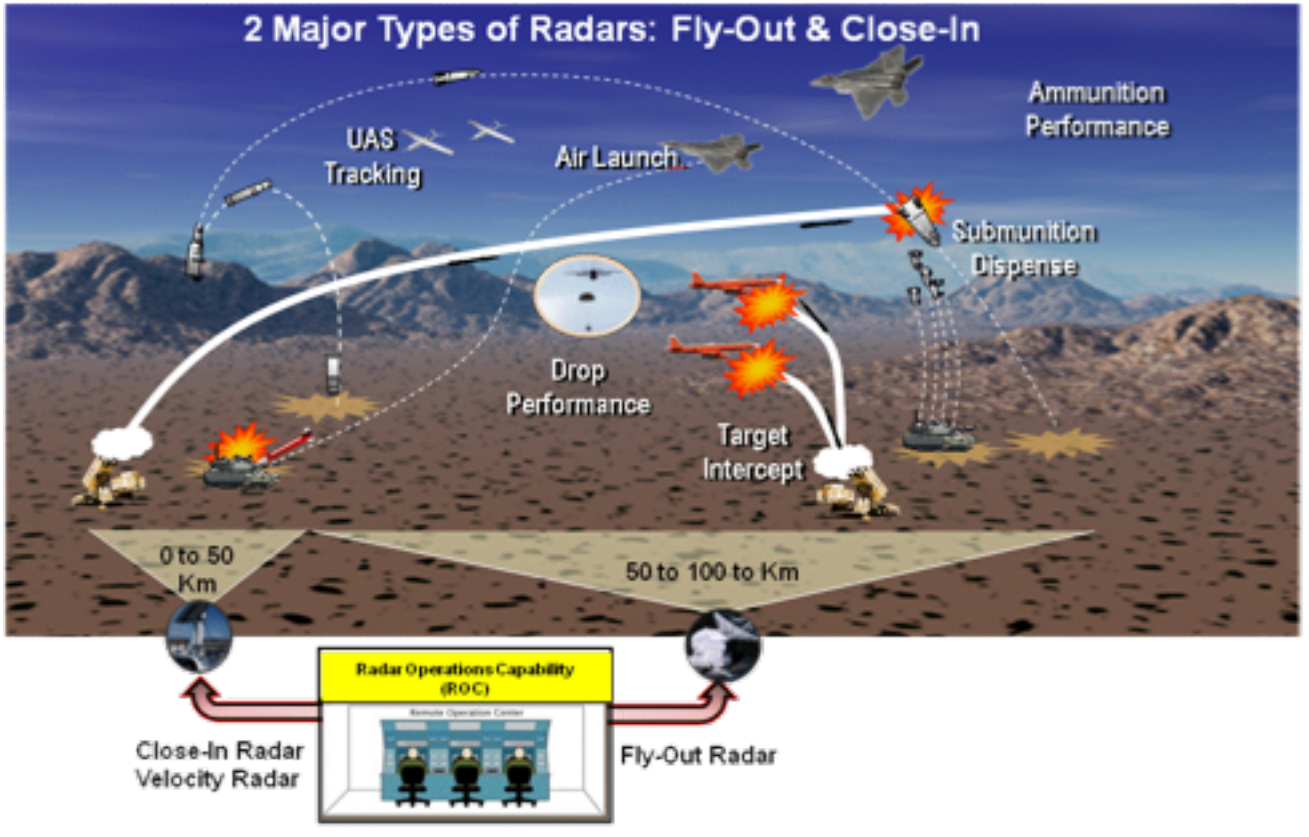


TENA and RRRP

- Use of TENA will facilitate Remote Operations and Interoperability of the Ranges' Radar Systems
- TENA Instrumentation Radar Object Models will be used for all communications external to the individual Radar Systems
  - Pointing data for optics, telemetry, or other radars
  - Remote Single Integrated Air Picture (SIAP)
- Development of TENA Instrumentation Radar Object Models
  - Developed initial Instrumentation Radar TSPI Object Model
    - Received input from Test Center SMEs
    - For CW Doppler and Pulse radar systems
  - Instrumentation Radar Object Models will be finalized after contract award

Range Radar Replacement Program (RRRP)

- **TENA specified in RRRP acquisition program requirements for radar system communication with other range systems**
  - TENA project supporting the design and evaluation of object models for these tracking radars that are planned to be deployed to WSMR, Yuma, Redstone, and Aberdeen ranges



TENA at Eglin Air Force Base

- **TENA supports Eglin's Joint Test and Training Operations Control Center (JTTOCC) in providing efficient, flexible real-time control of all resources required for safe air, land, and sea test and training 24x7 operations**

"TENA gave us a common environment that greatly simplified the efforts of our two non-co-located software development contractors. It also significantly aided in our ability to meet information assurance criteria, allowing us to move from requirements to fielding on the NIPRNet in under 18 months. "

Chris Short
JTTOCC Lead Systems Integration Engineer

Mobile Multi-Sensor TSPI System (MMTS) Project

- U.S. Army Program Executive Office (PEO) for Simulation, Training, and Instrumentation (STRI) awarded Photo-Sonics, Inc. a contract to build the Mobile Multi-Sensor Time-Space-Position-Information-System (MMTS)
- The MMTS consists of two high-performance optical tracking pedestals connected via fiber optics to a control van equipped with two remote control consoles, the system was designed to track and provide high accuracy Time-Space-Position-Information (TSPI) of high-speed weapons including hyper-velocity projectiles
- Functional testing and Final Site Acceptance Test completed at White Sands Missile Range (WSMR)
- Final system has been delivered and integrated via TENA Interface into Redstone Arsenal

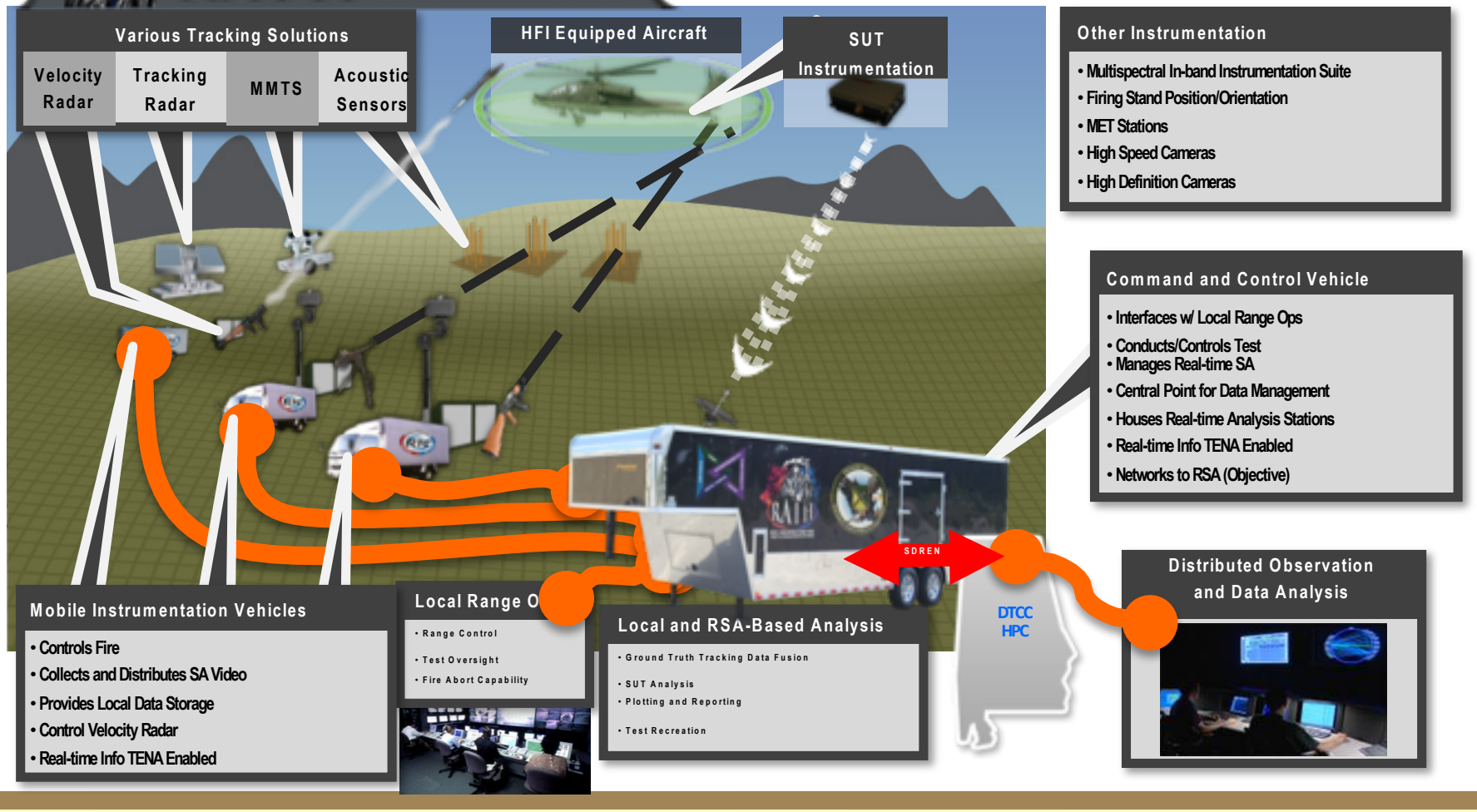
System Characteristics

- Fully Integrated Pedestal and Sensor Control Software
- Radar provides a Single Station Solution
- High-Speed Auto Tracker (250 FPS)
- High Accuracy
- High Dynamics
- Automated Stellar and Turn & Dump Calibration
- Simulation System
- Range Interface Computer to calculate real-time 3D data
- Integrated Data-Reduction Software (six degrees of freedom)
- TENA Integration into RTC

"TENA architecture was instrumental in the development of the interoperability between the MMTS and the Integrated Test Range. Implementing the various TENA modules was simple, smooth, and straightforward with no major effort needed."

Philip Kiel
President, Photo-Sonics

RTC/ASE Architecture for Test & Evaluation of Hostile Fire (RATH)



"Applying TENA has been a leading contributor to making disparate efforts (M&S, Lab, Hangar, Range) leverage duplicate capabilities to form an overall better test capability"

Mac Lowry
Advanced Technology Office Chief, Redstone Test Center

TENA Enabled OneSAF

- **One Semi-Automated Forces (OneSAF) is the U.S. Army's premier entity level computer generated forces (CGF) constructive simulation supporting full spectrum of military operations, systems, and control processes from brigade down to individual platform/combatant levels.**

- **OneSAF TENA interoperability components contain all the necessary TENA object models, Middleware, Java Bindings and scripts needed to build and run OneSAF v7.0 TENA interoperability capability. Instructions for this release are also posted on this website.**

OneSAF-TENA

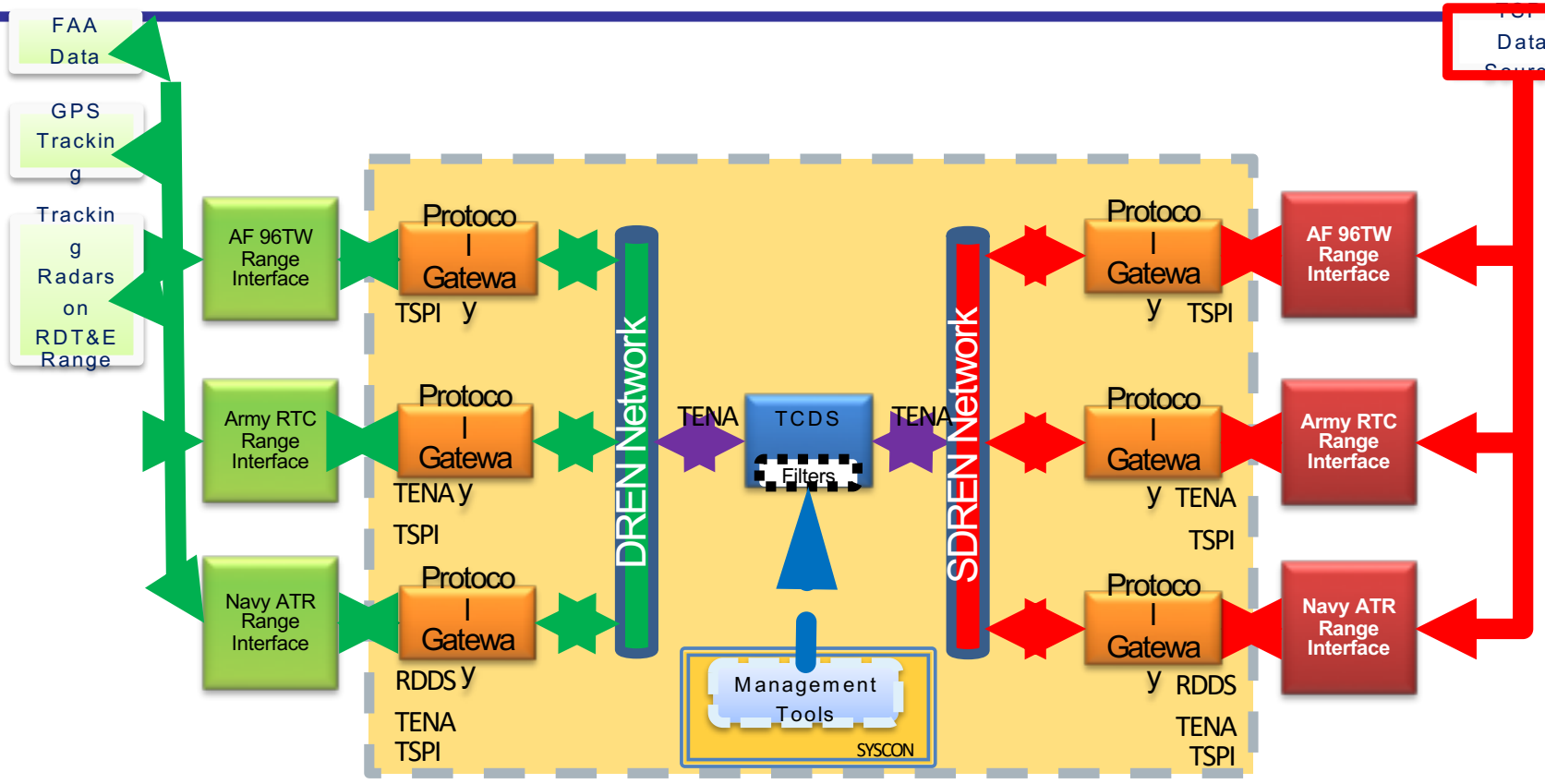
Interoperability

Use TENA natively with the U. S. Army's premier entity level constructive simulation

TENA Enabled TM Control at YUMA

- **TCS Antenna Control Unit (ACU) model M1 completing TENA interface**
- **Remote monitoring and control of telemetry antenna system using TENA is undergoing operational testing**
- **To be used on Yuma TM pedestals**
- **Updated controller to be procured this year with Red Hat 6 Operating System**

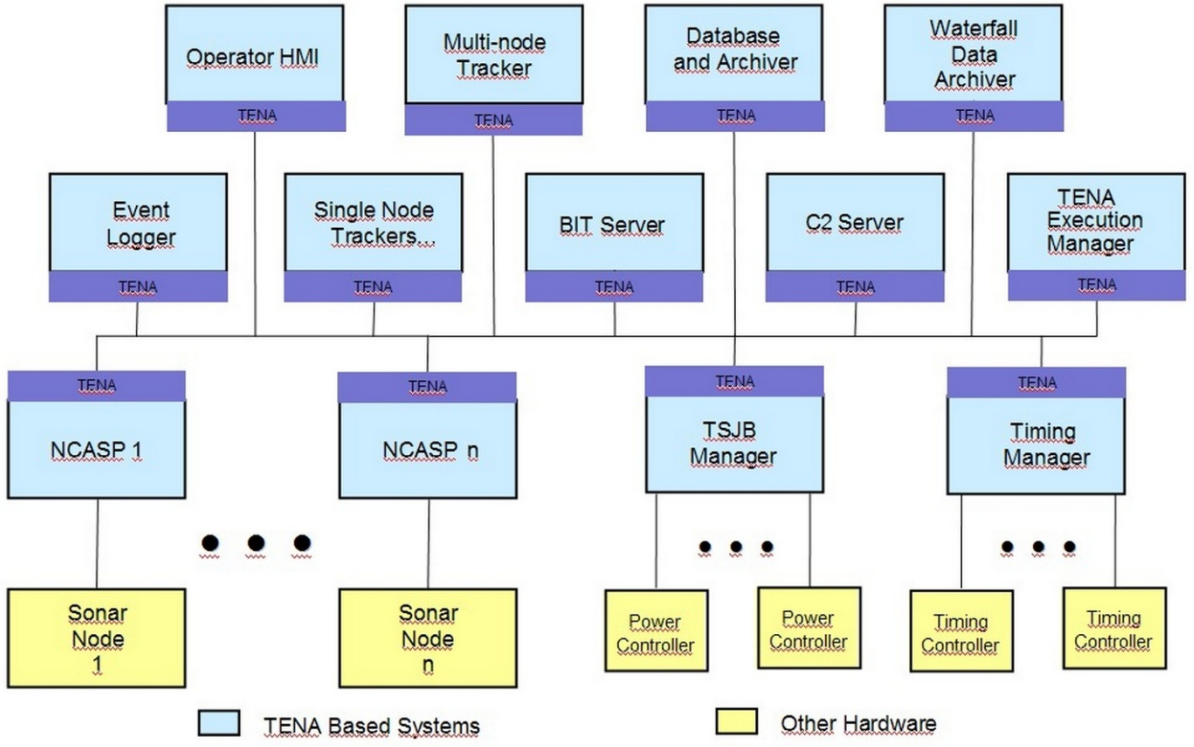
MLS-JCNE CDS System Design Diagram



The Goal of the Block 1 MLS-JCNE implementation is to provide the RDT&E community with a persistent, interoperable, and reusable capability to exchange unclassified data between unclassified and classified enclaves

Swimmer Detection System

- **Highly scalable, distributed, real-time underwater intruder detection system utilizing active sonar – operational system is integrated end to end using only TENA**
  - **Installed and operational "24x7" since 2010**

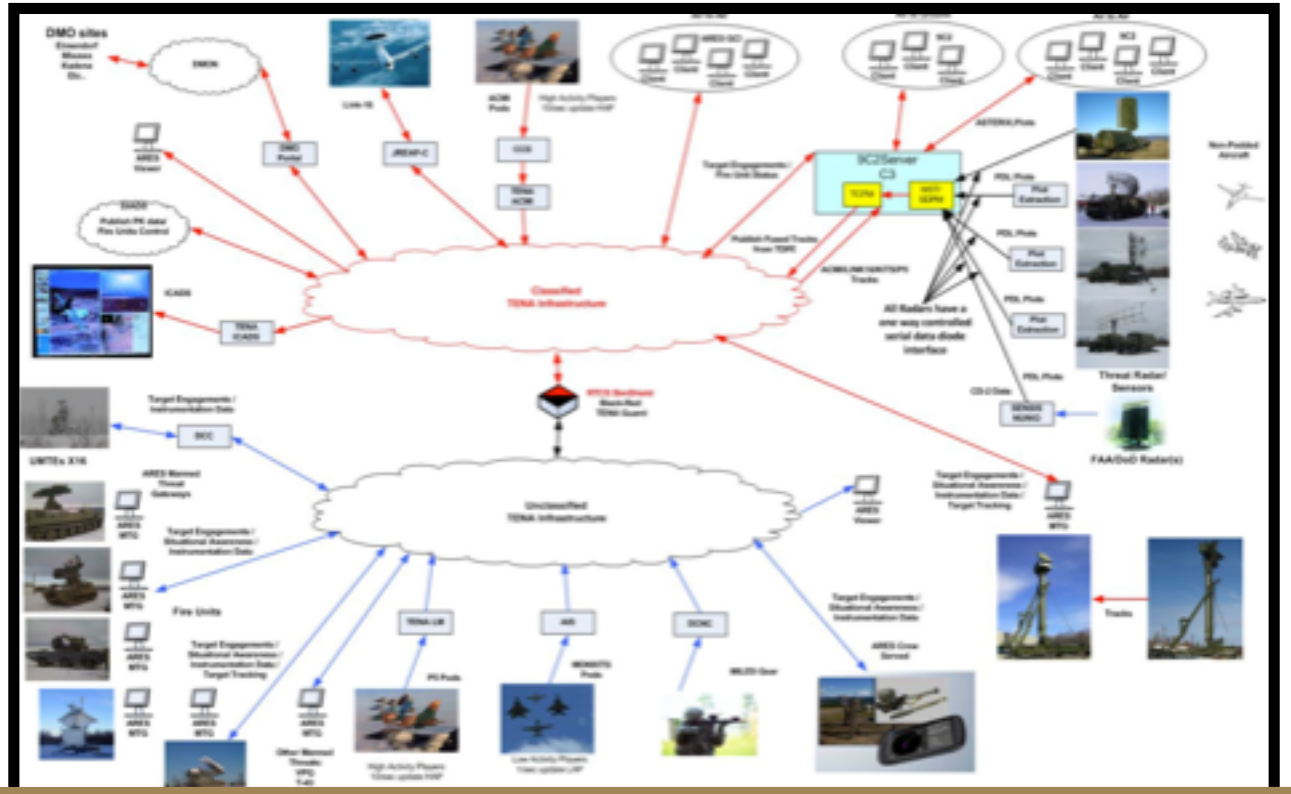


"Using TENA makes the almost-impossible almost easy. TENA flexibility and platform independence was essential."

C. Nylander
Senior Software Manager, Scientific Solutions

TENA at Joint Pacific Alaska Range Complex (JPARC)

- **TENA enables JPARC to provide force-on-force (FOF) training capability that fully integrates and supports joint and coalition components for both air and ground training in live, virtual, and constructive (LVC) domains**



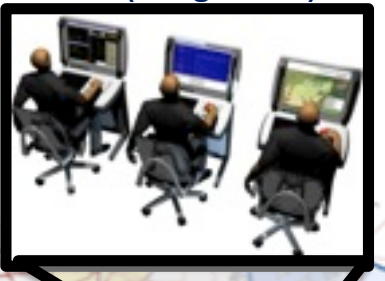
"TENA is the greatest thing that ever happened to us. We couldn't be doing today with all these systems–and we couldn't have all the participants that we do–if it weren't for TENA"

Billy D. Smith
Chief of electronic combat training requirements for Red Flag at JPARC

Advanced Remote Control Telemetry System (ARC-TS) NAVAIR Atlantic Test Range (ATR) Operational View (OV-1)

Remote Operations:

- Power Controllers
- TM Antennas
- TM Receivers
- Spectrum Analyzers
- Oscilloscopes
- Bit Sync



ARC-TS Roadmap Overview

FY 2015 FY 2016 FY 2017

Current

End State

Cost Savings (Remote Manning / Travel)

Autonomy and Maintainability

Remote Operations Functionality

TCS Remote Control

Malibu & Orbit Status & Remote Control

TCS Status

Luminstar Receiver

Testing Palmdale

Testing Wallops

Testing At Pax

Supervisor's Console (Access Controls)

SEMCO Receiver

Addressable Power Strip

Testing Lab

GDP Bit Sync

VISA Standard (SpecA & O-Scope)

Real-Time Remote Operator Stations (CROS)

Common Interfaces
Remote Operations
Status Displays
Remote Operator Console
Supervisor Access Controls

RDDS → TENA Protocol Translator

Notional ROS

Status Displays

Integrated Threat Force (ITF)

- **The Integrated Threat Force (ITF) provides the Army Test and Evaluation Command (ATEC) a scaled threat force against which BLUEFOR (Blue Force) systems, and systems of systems, are tested during their Operational Evaluation Events**

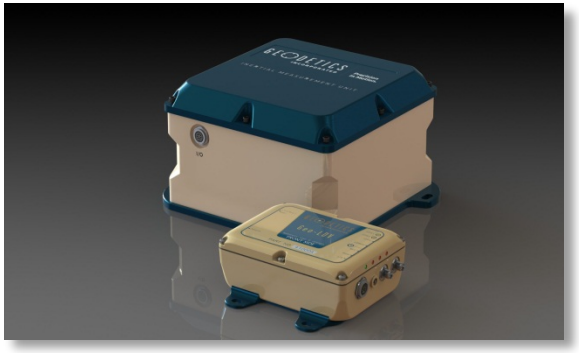
"TENA has enabled us to bring together many systems which don't typically work together. The object oriented design of the object models and middleware … allow for the quick production of adapters to legacy systems. Without TENA, this would be a much more complicated and expensive program."

Brett Kaylor
ITF Lead Software Architect

Geodetics Inc.

- Geodetics produces a range of TENA Enabled high-accuracy real-time TSPI solutions for tracking dismounted soldiers and low to high-dynamic platforms

PDSU TSPI for Dismounted Soldiers



Geo-LDV TSPI for Manned and Unmanned Vehicles

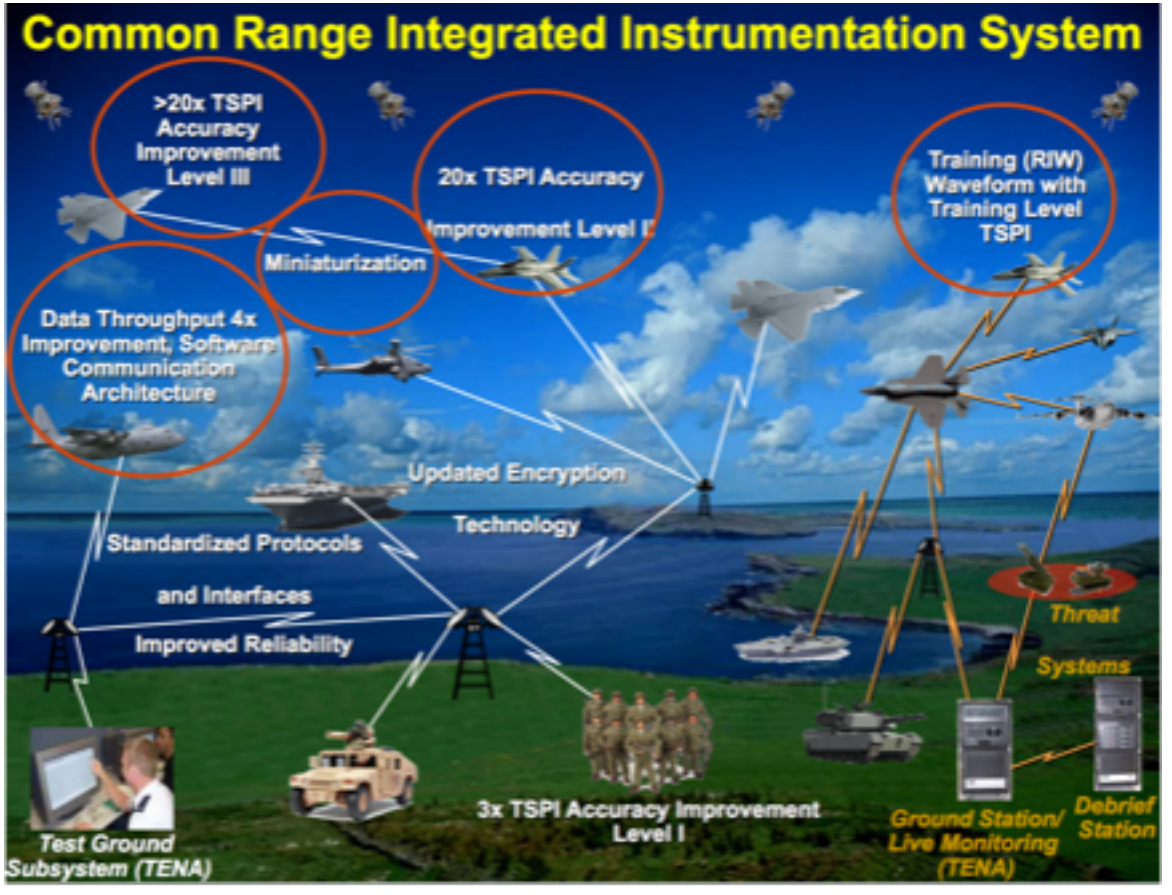
Geo-TRX

"Integration with TENA took only 3 weeks and enhanced our products with distributed test and training capabilities as well seamless integration with a wide range of standard tools widely used by the T&E and Training communities"

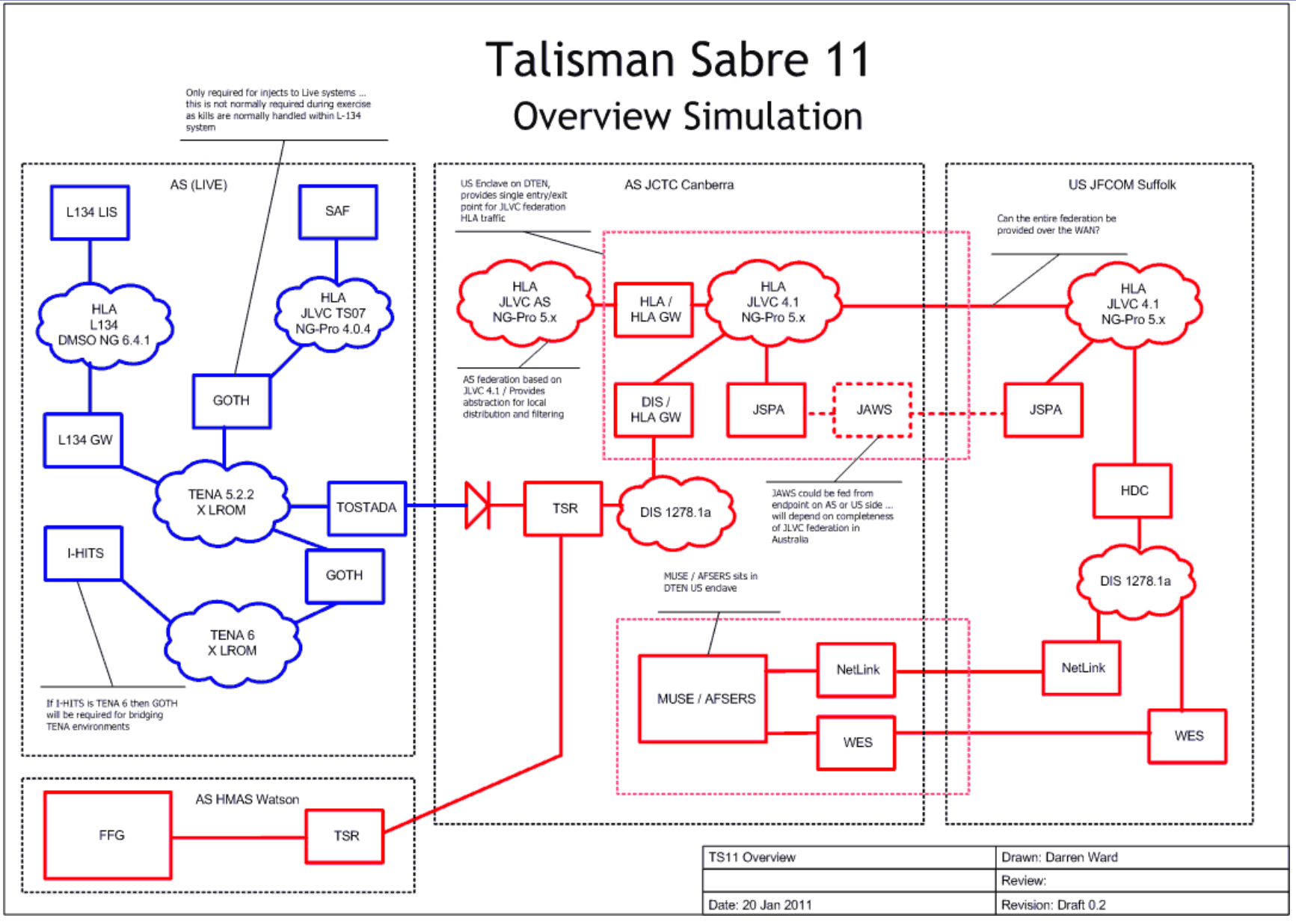
Dr. Jeffrey Fayman
Vice President Business and Product Development

Common Range Integrated Instrumentation System (CRIIS)

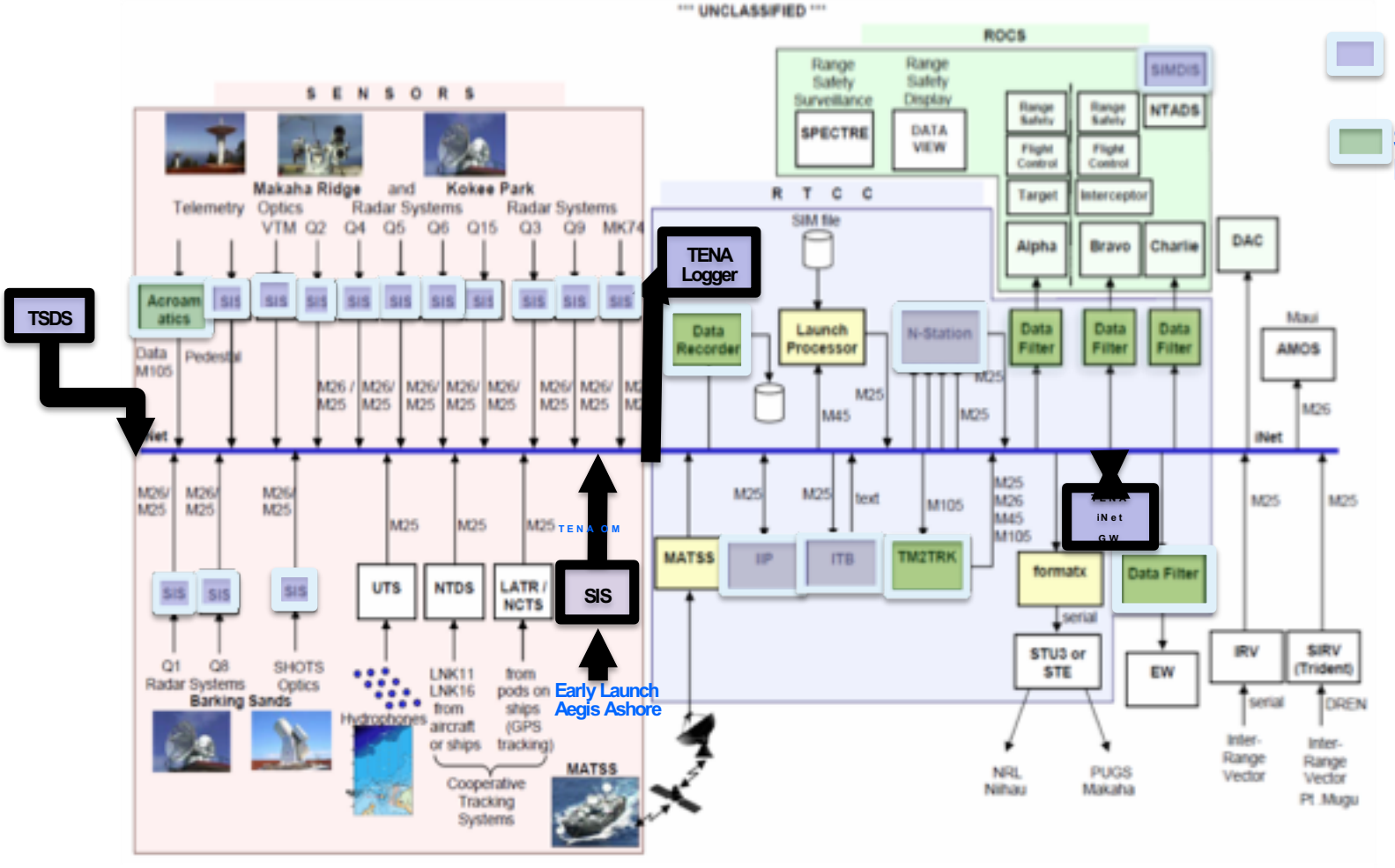
- **TENA specified in CRIIS acquisition program requirements for ground system communication**
  - TENA project providing port to Green Hills Real-Time Operating System, which is used in ground stations and air platforms



Talisman Sabre 2011Applications from PARC and JNTC



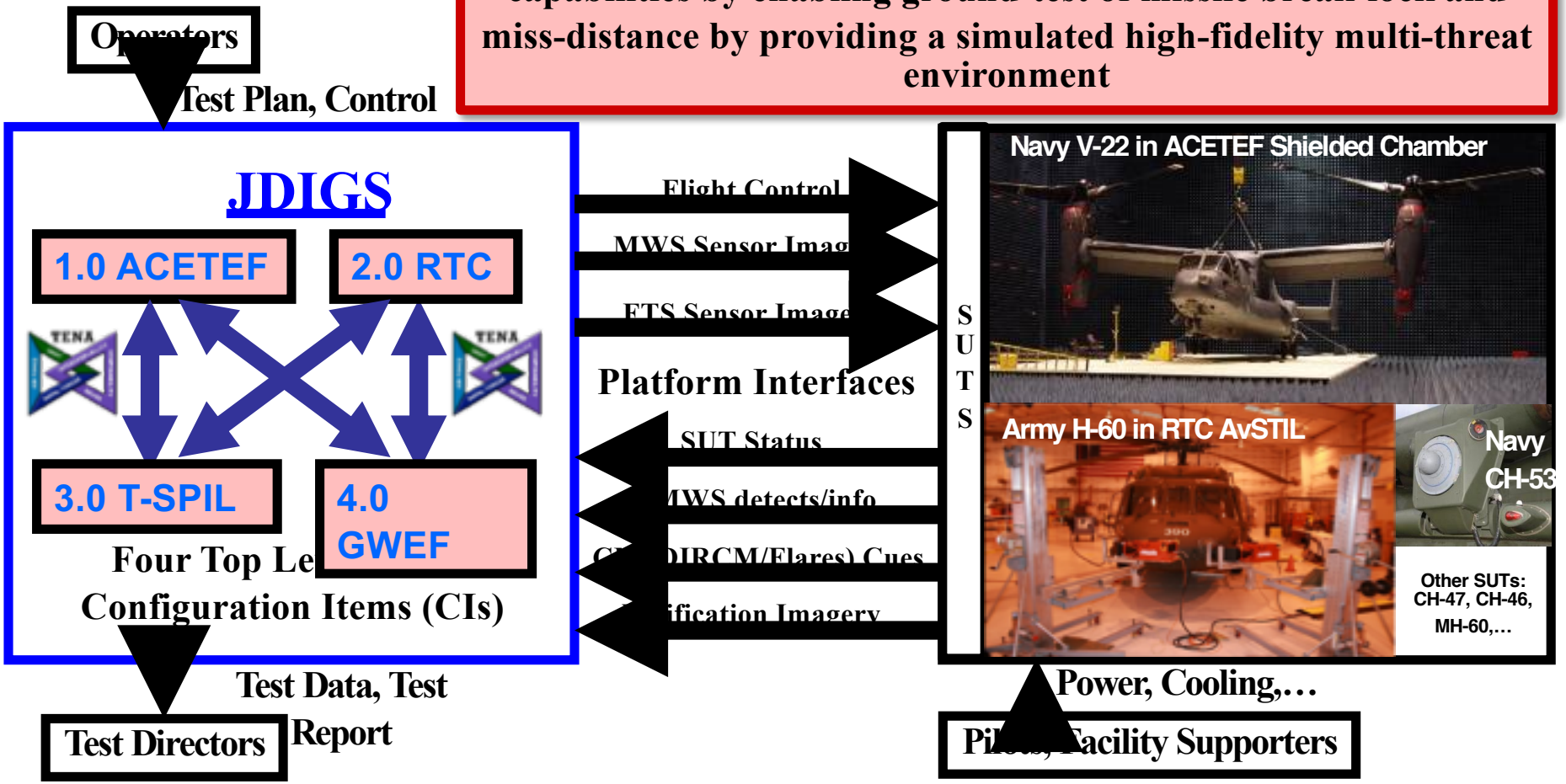
PMRF Migration to TENA Architecture



"PMRF's high-level direction for future information technology is to move to the TENA Object Model standard for information exchange between PMRF systems and between PMRF and other ranges" PMRF Tech Director

Joint Distributed IRCM Ground-Test System (JDIGS)

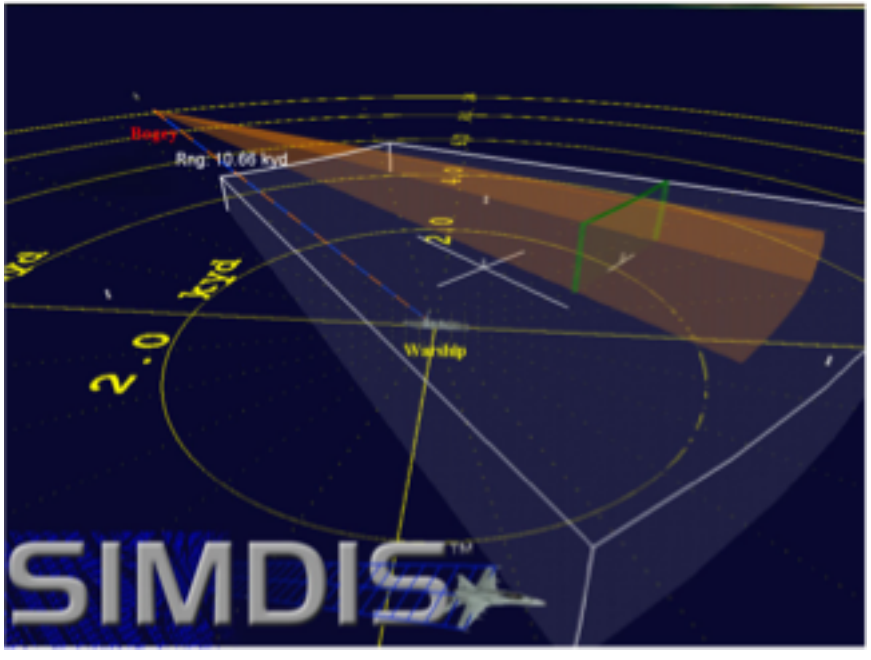
JDIGS is a tri-service project that upgrades IRCM T&E capabilities by enabling ground-test of missile break-lock and miss-distance by providing a simulated high-fidelity multi-threat environment



IRCM = IR Countermeasures, MWS = Missile Warning System, FTS = Fine Tracking Sensor part of DIRCM.

SIMDIS Analysis and Display Tool

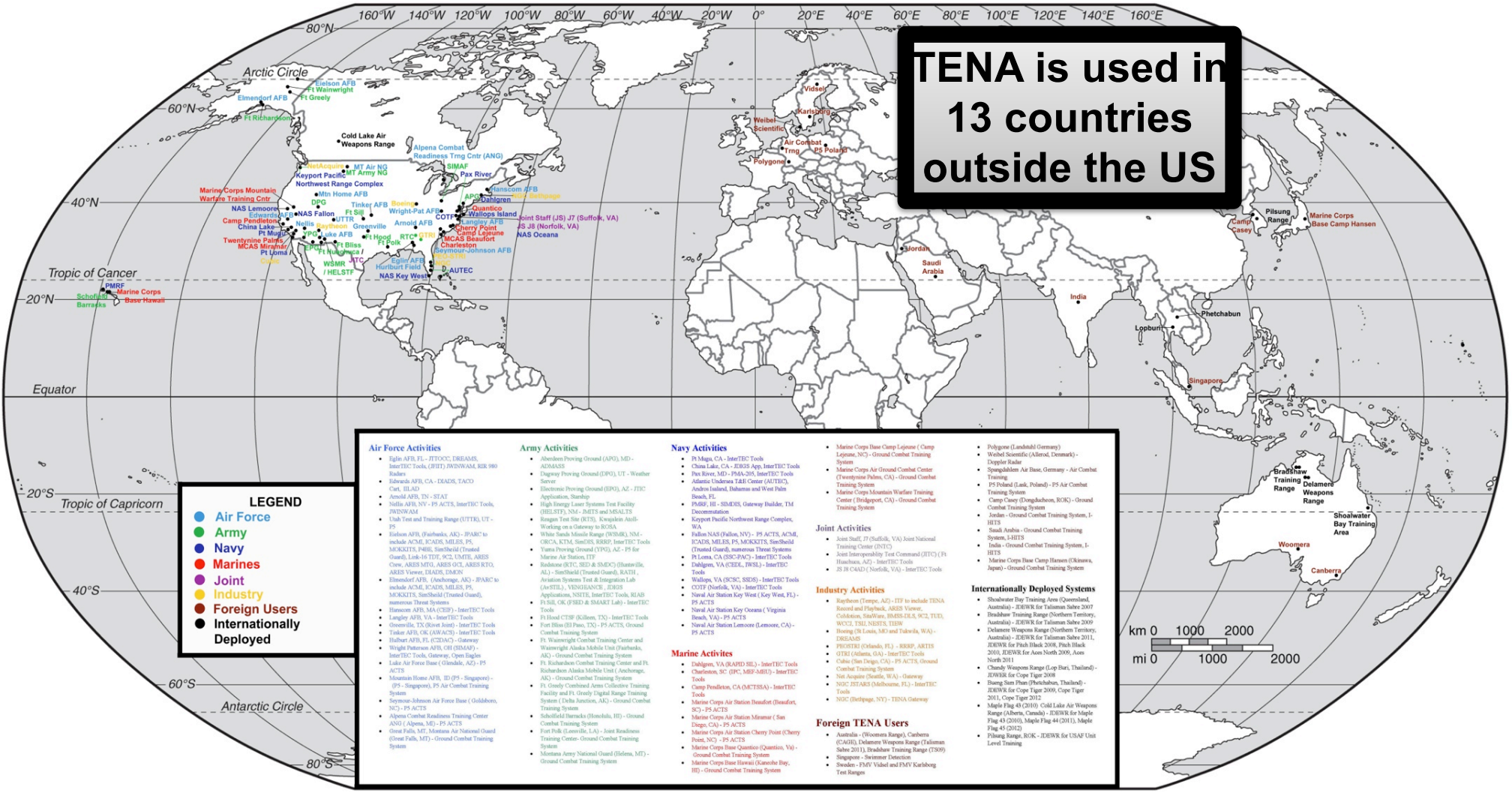
- **SIMDIS™ is a set of software tools that provide two and three-dimensional interactive graphical and video display of live and post processed simulation, test, and operational data.**
  - **In collaboration with TENA SDA, SIMDIS supports a binary and source code version of a TENA plugin which enables SIMDIS to display and support analysis of data from TENA events**



"TENA offers extensibility to add new data sources and protocols as they become available without impacting the existing SIMDIS software."

William Doughty
Naval Research Laboratory, SIMDIS Developer

Worldwide Use of TENA



TENA Utilities and Tools (Partial List)

- **TENA Utilities—Making TENA easier to use**
  - MagicDraw UML-to-TDL Plugin
  - TENA Integrated Development Environment
  - TENA Wiki (Confluence)
  - TENA Issue Tracking System (Jira)
  - TENA Installer
- **TENA Tools—Helping you manage your event**
  - TENA Console
  - Gateway Builder
  - Interface Verification Tool
  - SIMDIS
  - TENA Video Distribution System
  - Network Analysis Tools
  - Network Communication Tools (chat, file transfer, etc.)
  - Reflect Data Collection System
  - TENA AMO Monitor
  - SimShield Trusted Guard
  - Joint Interoperability Modular Evaluation System (JIMES)
  - Starship

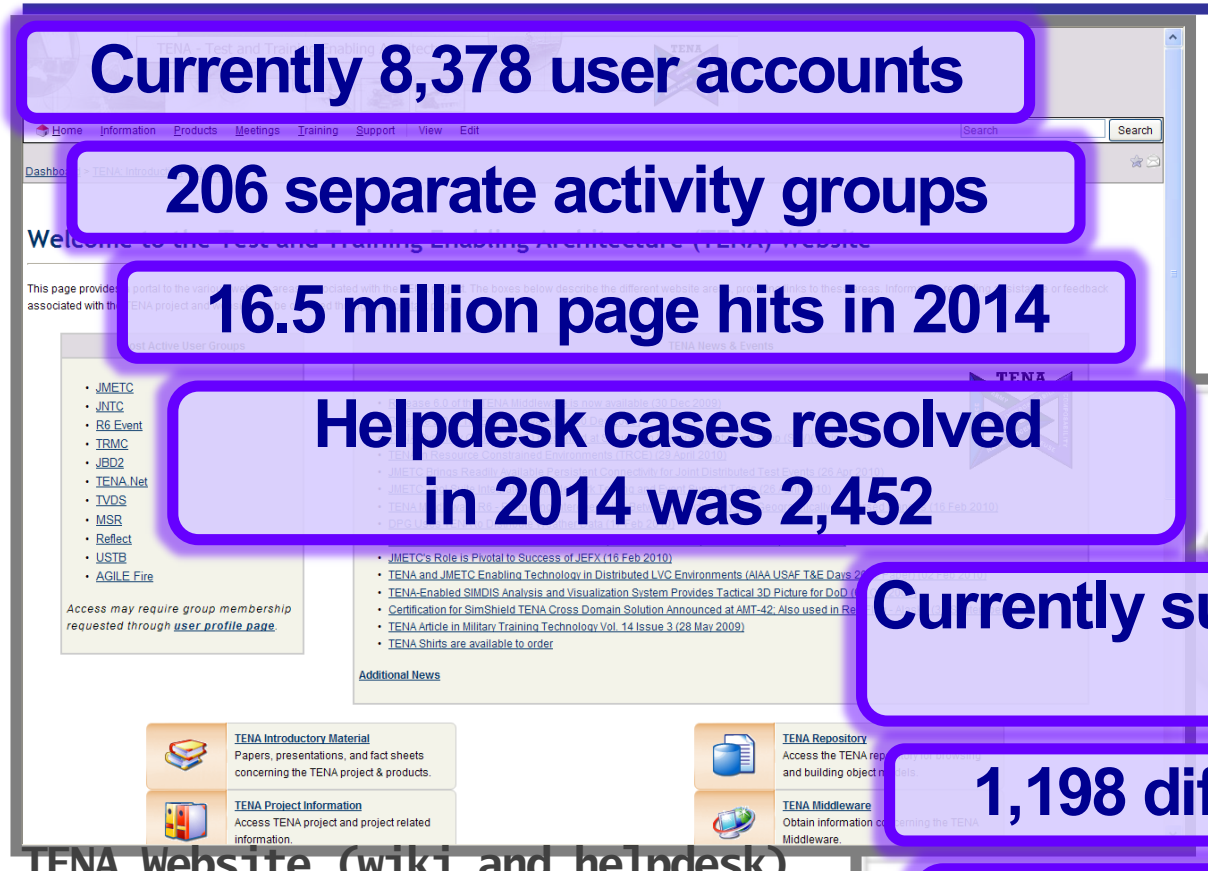
TENA Website Services
https://www.tena-sda.org/

Currently 8,378 user accounts

206 separate activity groups

16.5 million page hits in 2014

Helpdesk cases resolved in 2014 was 2,452



TENA Website (wiki and helpdesk)

TENA Software Repository

Currently supporting 40 computer platforms

1,198 different object models

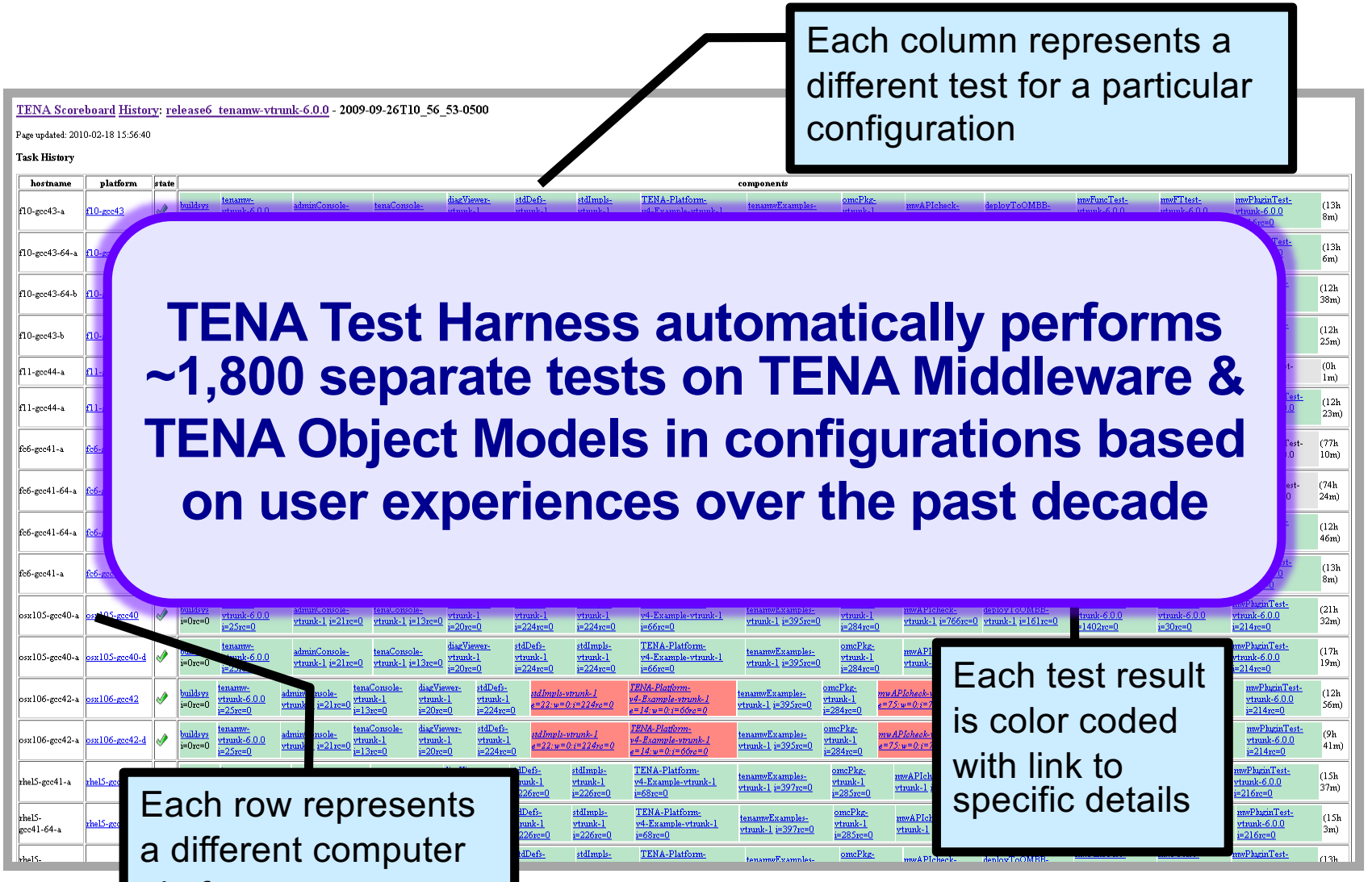
Repository software downloads of 2,877 in 2014

727 middleware development kits downloaded in 2014

TENA Standard Object Models

- **Platform Related**
  - TENA-Platform-v4
  - TENA-PlatformDetails-v4
  - TENA-PlatformType-v2
  - TENA-Embedded-v3
  - TENA-Munition-v3
  - TENA-SyncController-v1
  - TENA-UniqueID-v3
- **JNTC OMs (for Training)**
  - JNTC-AirRange-v2
  - JNTC-CounterMeasure-v2
  - JNTC-IndirectFire-v2
  - JNTC-Instrumentation-v2
  - JNTC-NBC-v2
  - JNTC-ObstacleMinefield-v2
  - JNTC-Threat-v2
- **Time-Space Position Information (TSPI) Related**
  - TENA-TSPI-v5
  - TENA-Time-v2
  - TENA-SRFserver-v2
- **Others**
  - TENA-AMO-v2
  - TENA-Engagement-v4
  - TENA-Exercise-v1
  - TENA-GPS-v3
  - TENA-Radar-v3.1
- **In Progress**
  - TENA-TelemetryMeasurand-v1
  - TENA-Weather-v1
  - Additional JNTC OMs for training

TENA Automated Test Harness



Each column represents a different test for a particular configuration

TENA Test Harness automatically performs ~1,800 separate tests on TENA Middleware & TENA Object Models in configurations based on user experiences over the past decade

Each test result is color coded with link to specific details

Each row represents a different computer platform

TENA User Documentation

- Middleware -v6 User Guide
- Middleware Introduction -v6
- Object Model -v6
- Application Development -v6
- Middleware Services -v6
  - Configuration Mechanism -v6
  - Execution Management Services -v6
  - Publication Services -v6
  - Subscription Services -v6
    - Observer Mechanism -v6
    - Callback Framework -v6
    - Object Model Subsetting -v6
    - Subscription Slicing -v6
  - Advanced Filtering -v6
    - Filtering Context -v6
      - Computing Filtering Context based on State Update -v6
    - Filter -v6
    - Stateful Distributed Object -v6
  - Middleware Threading Model -v6
  - Middleware IDs -v6
  - Middleware Metadata -v6
- Execution Manager -v6
- Message -v6
  - Message Sender -v6
  - Message Constructor -v6
  - Message Implementation Registration -v6
  - Message Subscription -v6
  - Message Inheritance and Polymorphism -v6
  - Message Unsubscribe -v6
  - Message ID -v6
  - Adding Message Support to Existing Application -v6
- Local Class -v6
- Event Management -v6

Advanced Filtering

Nominally, the publish-subscribe behavior of the middleware operates on matching the object model type being published with the type of interest for the subscriber. Advanced filtering extends this type-based filtering to allow publishers and subscribers to provide additional criteria to provide finer control of subscription interests to minimize the amount of unwanted information that would occur with a pure type-based filtering system.

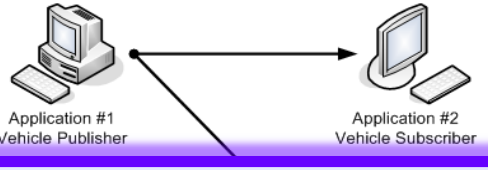
Description

The TENA Middleware provides a peer-to-peer publish and subscribe capability in which the underlying software connects publishers with interested subscribers. Once connected, a publisher will attempt to provide the data of interest to the subscriber. The TENA Metamodel supports Stateful Distributed Objects (SDOs) and Messages that can be exchanged between publishers and subscribers. A key objective in many distributed publisher-subscriber systems is to minimize the unwanted data that is sent to the subscribers, for the purpose of improving network utilization and minimizing unnecessary computer processing. If the subscribing application has to perform "receive-side" filtering to throw away a large percentage of received network messages, there is wasted computer resources in sending and processing the unwanted network messages.

Note that the term "object" will be used in the following discussion to represent either an SDO Servant or an SDO Proxy, depending on whether the object exists in the publishing or subscribing application, respectively.

A primary technique that is used to support publisher-subscriber filtering is based on the particular data types defined in the object model. Type-based filtering ensures that a subscriber will only receive data associated with either an SDO or Message type that matches a subscription request made by the subscribing application. For example, if an object model includes an SDO type named `Vehicle`, and if a subscribing application only subscribes to the `Vehicle` SDO type, then any other data that is published in the execution will not be delivered to the subscribing application.

A simple illustration of type-based filtering is shown in the figure below. In this hypothetical scenario, Application #2 only subscribes to type `Vehicle` and will not receive any of the `Person` data published by Application #3. Application #4 subscribes to both type `Vehicle` and type `Person`, so it will receive data from both Application #1 and Application #3.



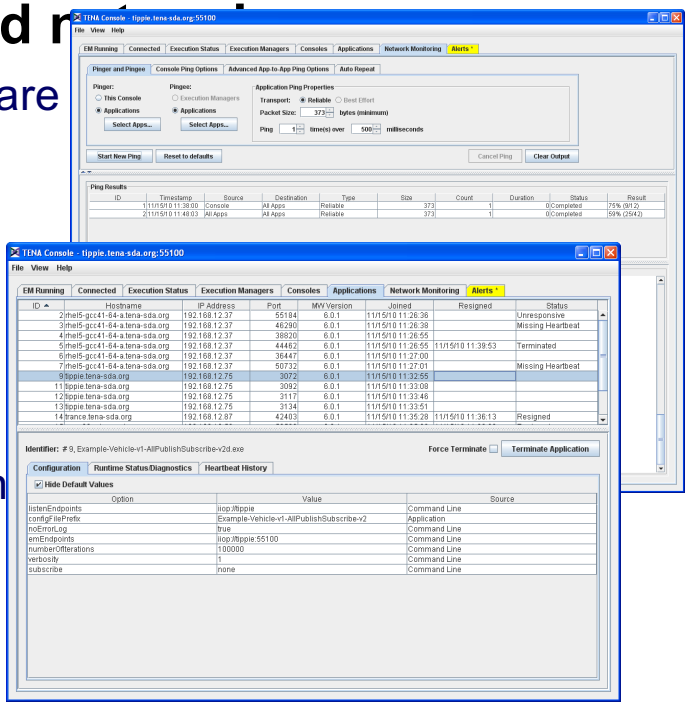
Extensive user documentation that includes code examples and practical guidance for middleware and related products

Test Construction / Setup: TENA Tools

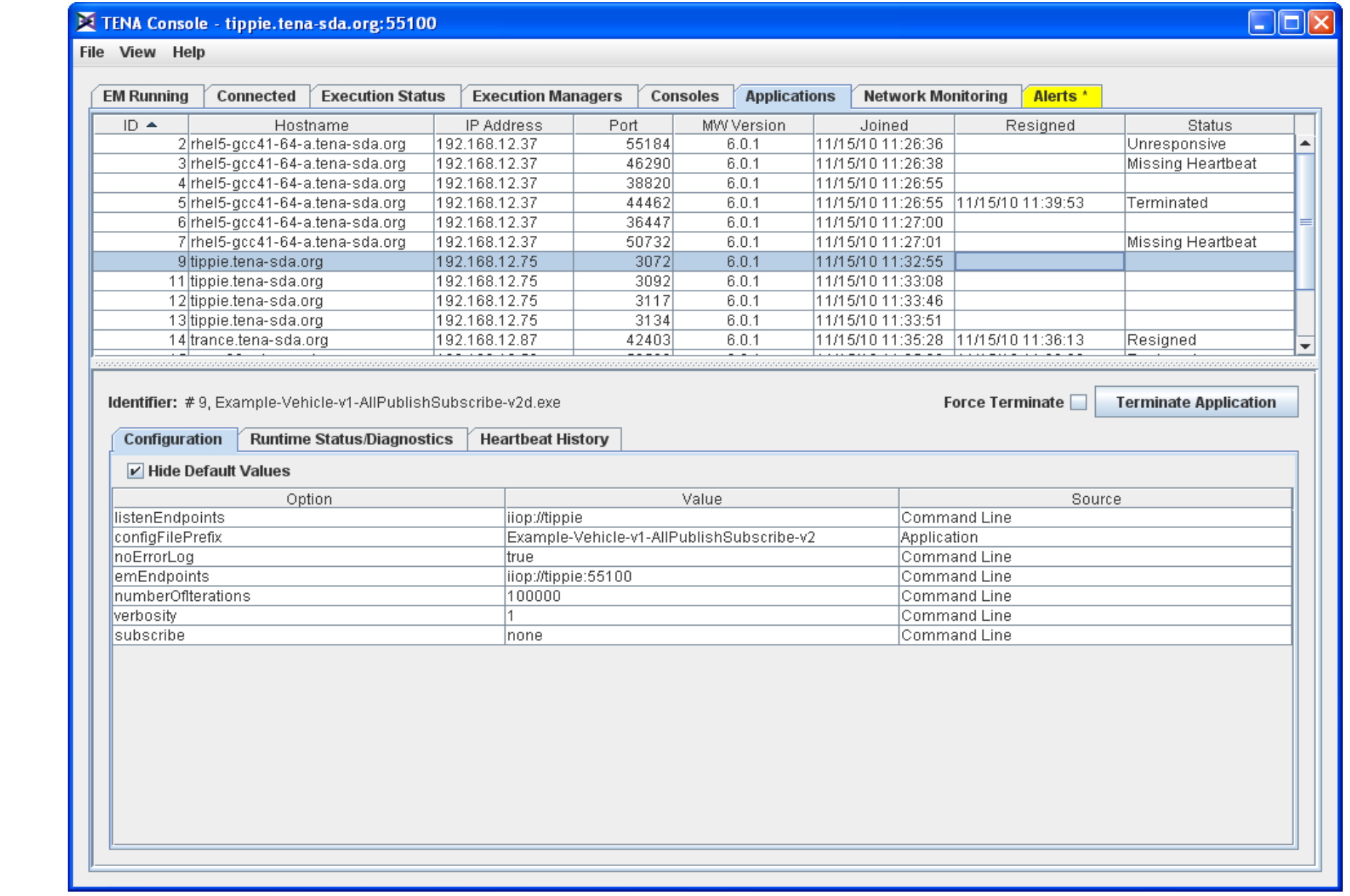
- **Tools are applications, components, or utilities required to support a successful test execution**
- **The TENA SDA maintains a library of tools that address common test requirements**
  - Common tools enable a consistent depiction of the test environment
  - All tools and supporting documentation available through the TENA Repository
- **Some example tools include:**
  - Collaboration and Sharing: TENA Repository
  - Help Desk and Troubleshooting: TENA Issue Tracking System
  - OM Design Support: MagicDraw UML-to-TDL Plugin
  - Legacy Test Asset Integration: TENA Adaptor
  - Test Event Management: TENA Console
  - 3D Visualization: SIMDIS TENA Plug-in
  - Video Sharing: TENA Video Distribution System
  - Data Logging: TENA Data Collection System

TENA Console

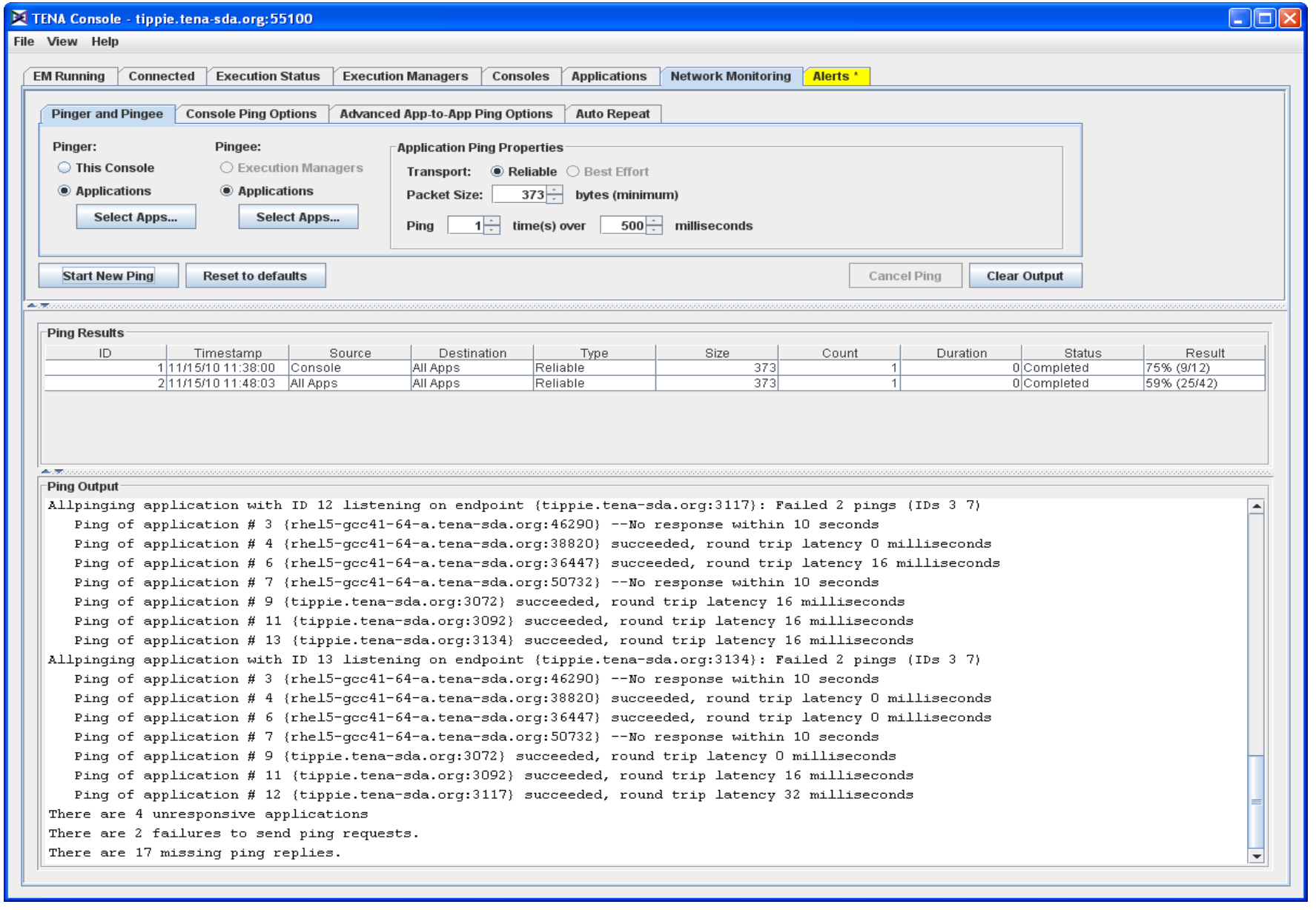
- **TENA Console is a GUI-based event management tool used to evaluate and monitor applications and n**
  - Utilizes capabilities automatically built into the middleware
  - Multiple TENA Consoles can be run anywhere on the network
- **Application Diagnostics**
  - Evaluate middleware and application configuration
  - parameters to detect incorrect settings
  - Obtain runtime diagnostic values related to the state an
  - performance of the application
- **Network Monitoring**
  - Perform TCP and (unobtrusive) UDP Multicast “ping” operations between applications to test communication
  - Establish continuous ping operations to notify operators of transient network problems
- **Application Alerts**
  - Notify operators of application warnings that require investigation



TENA Console



TENA Console



Key Release 6 Improvements and New Capabilities

New Middleware Capabilities

- Advanced Filtering
- OM Subsetting Support
- SDO State Processing Support
- Self-Reflection Option
- Object Reactivation
- Separate Inbound/Outbound ORBs

Metamodel and Model Improvements

- Fundamental Sized Type Aliases
- Const Qualifier
- Optional Attributes
- SDO Initializers
- Middleware Metadata
- Middleware IDs

New Event Management Capabilities

- Object Model Consistency Checking
- Remote Object Termination
- Execution Manager Fault Tolerance
- Embedded Diagnostics
- TENA Console

Usability Improvements

- Observer Pattern (with Callback Aggregation)
- Local Methods Factory Registration
- Code Installation Layout

Key Release 6 Improvements and New Capabilities

New Middleware Capabilities

- Advanced Filteri
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- ivation
- rate Inbound/Outbound ORBs

•Enhanced data distribution
•Optimized network usage

Metamodel and Model Improvements

- Fundamental Si
- Const
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- eware IDs

•Better ways to define data
•Remove ambiguity

New Event Management Capabilities

- Object Model
- Rem
- olerance
- stics
- sole

•Improved reliability
•Enhanced troubleshooting

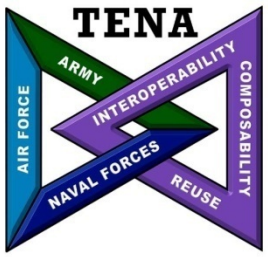
Usability Improvement

- Observer Patt
(with
- allation Layout

•Easy to use
•Harder to use wrong

Release 6 Platform Support

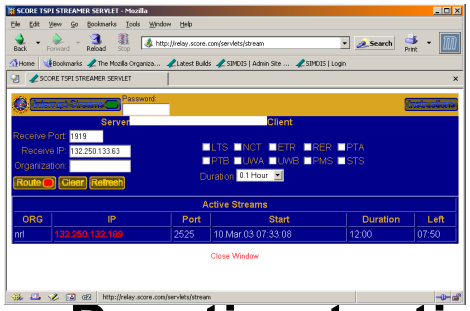
- Linux Fedora Core 6
- Linux Fedora Core 6, 64-bit
- Linux Fedora 12
- Linux Fedora 12, 64-bit
- Linux Red Hat Enterprise Workstation 4
- Linux Red Hat Enterprise Workstation 4, 64-bit
- Linux Red Hat Enterprise Linux 5.2
- Linux Red Hat Enterprise Linux 5.2, 64-bit
- Linux openSUSE 11.latest
- MAC OS X 10.6, Snow Leopard (Intel 64-bit)
- Windows XP, Visual Studio 2005
- Windows Server 2003, 64-bit, Visual Studio 2005
- Windows XP, Visual Studio 2008
- Windows Vista, Visual Studio 2008



Interface Verification Tool (IVT)

- **Designed to support the integration testing of TENA applications**
  - TENA Standard OM's
  - JNTC and InterTEC LROM's
- **Provides real-time monitoring, logging and statistics gathering**
- **Operates in three different roles, either stand-alone or in combination:**
  - Data Subscriber Role
  - Data Publisher Role
  - DIS to TENA Gateway Role

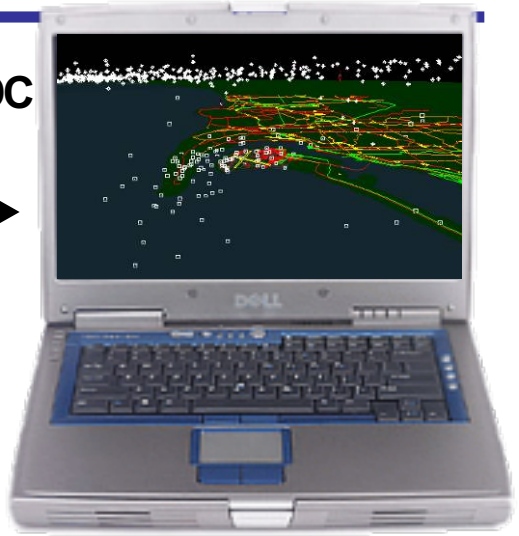
SIMDIS Use of TENA



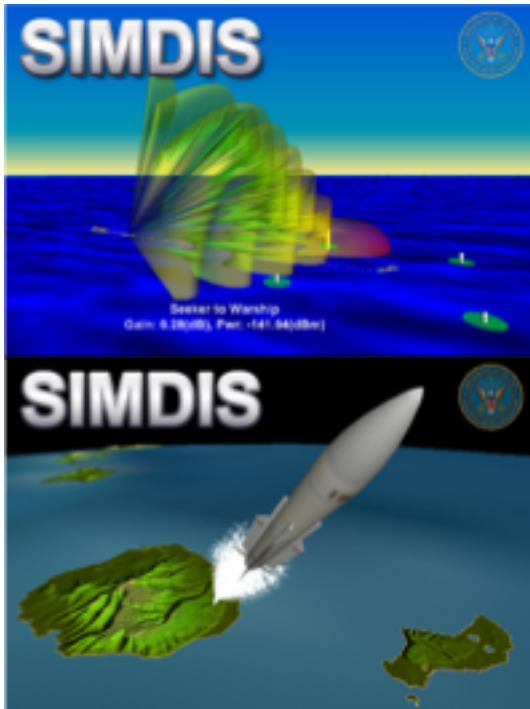
Southern California

TENA

NRL Washington, DC



- **Duration testing using SCORE TSPI data feed**
  - Four consecutive days
    - Win XP, Red Hat 9, Solaris 5.8
    - Processed 180,000+ entities
  - Two consecutive days
    - Win XP, Red Hat 9
    - Processed 53,000+ entities
- **Results and observations**
  - No issues with discovery latency
  - No issues with update latency
  - No issues with CPU usage
  - No issues with memory usage



Test Analysis / Reporting: Data Collection and Analysis Framework

- **Data Collector**
  - Using TENA object models, data collection software is automatically generated to record object and message attribute values in a persistent data store (currently SQLite and MySQL database representations)
  - Plan to provide add-on collection capability to allow publisher side collection, as well as subscriber side collection – which requires collection management capabilities
- **Data Analysis Support**
  - Extractor tool provided to convert data into format that can be used by Microsoft Excel
  - Analysis capabilities and tools are often highly specialized, and the intent of TENA is to provide a framework for user community to extend to support their unique data storage and analysis needs
- **Data Playback**
  - Automatically generated playback tool can be used to re-play collected data for various forms of testing and analysis

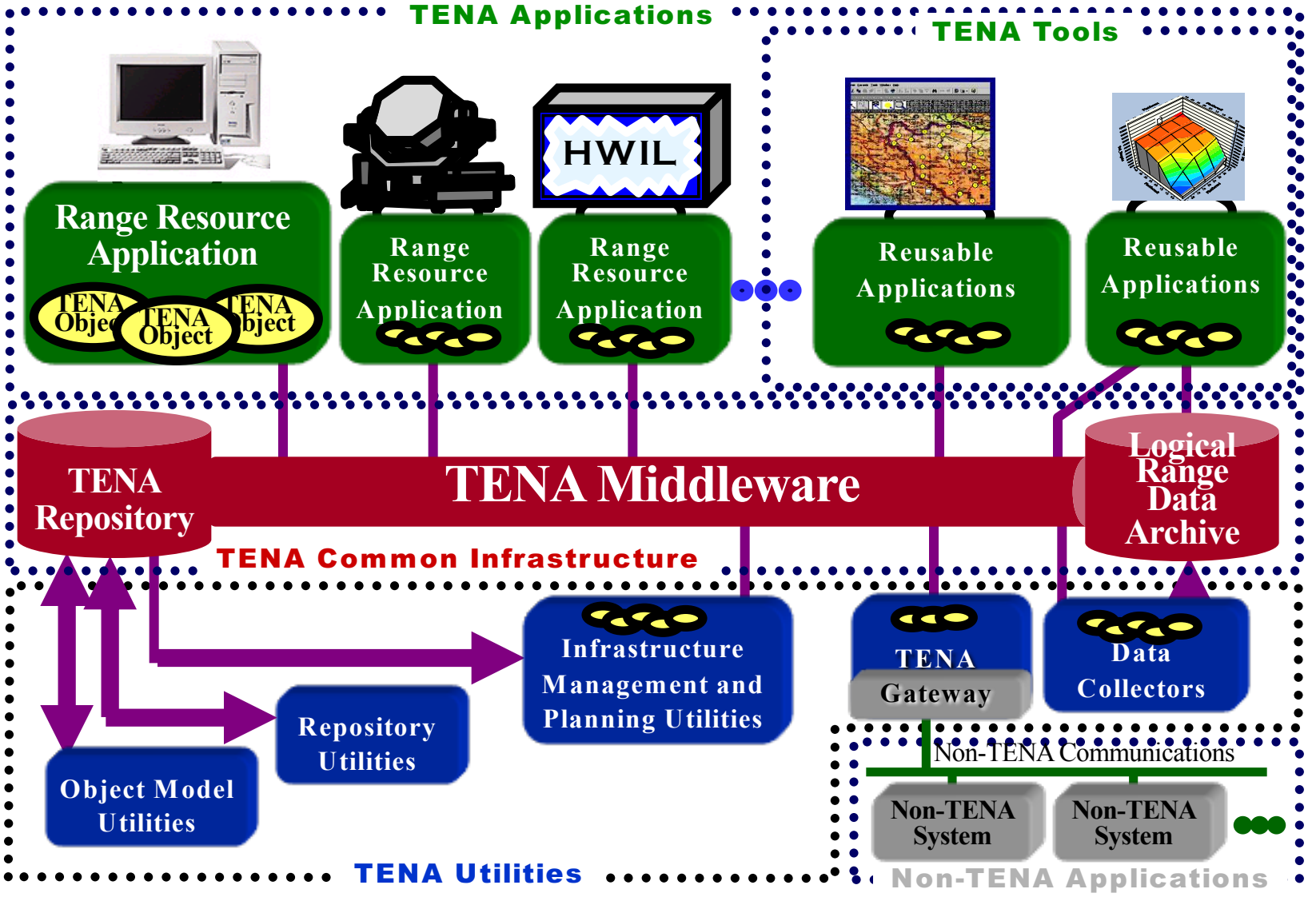
Summary: Benefits of TENA

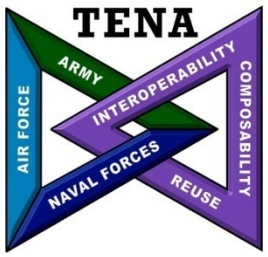
- **TENA represents an enormous amount of practical experience focused on addressing common range infrastructure requirements**
  - More than 7,000 registered users who have contributed to making TENA support their needs
  - More than 170,000 user downloads of middleware and object models used across the range community
- **TENA's technical approach emphasizes cost savings and reliability**
  - The TENA software is hard to use wrong
  - TENA catches many user errors at compile time rather than run time
  - TENA tools provide unprecedented understanding of a distributed event
- **TENA auto-code generation capability simplifies the creation of quality range infrastructure code**
  - Auto-generated example applications mean you never start with a blank page
  - Rapid development of real-time, distributed, LVC applications
  - Auto-generated test programs make integration a snap
- **TENA has many standard object models enhancing interoperability**
  - Building blocks already exist for common data structures and algorithms
  - More than 1,200 user object models exist in the TENA Repository for reusability
- **All TENA software and support is free to users**
  - TENA is the most capable and sophisticated interoperability solution for the range community
  - TENA software is thoroughly tested and very reliable
  - The TENA web site/repository has extensive documentation, training, and collaboration capabilities
- **TENA has a plan for continued evolution and funding to execute this plan!**

What is an Architecture?

- An architecture is a **segmentation** of a system (or system of systems) such that the primary pieces are identified, as well as their purpose, function, interfaces, and inter-relatedness, along with guidelines for their evolution over time
- Architectures put constraints on developers. These constraints make possible the achievement of higher level goals.
- These higher-level goals are called the system's **driving requirements**
- An architecture is a **bridge** from requirements to design

TENA Architecture Overview





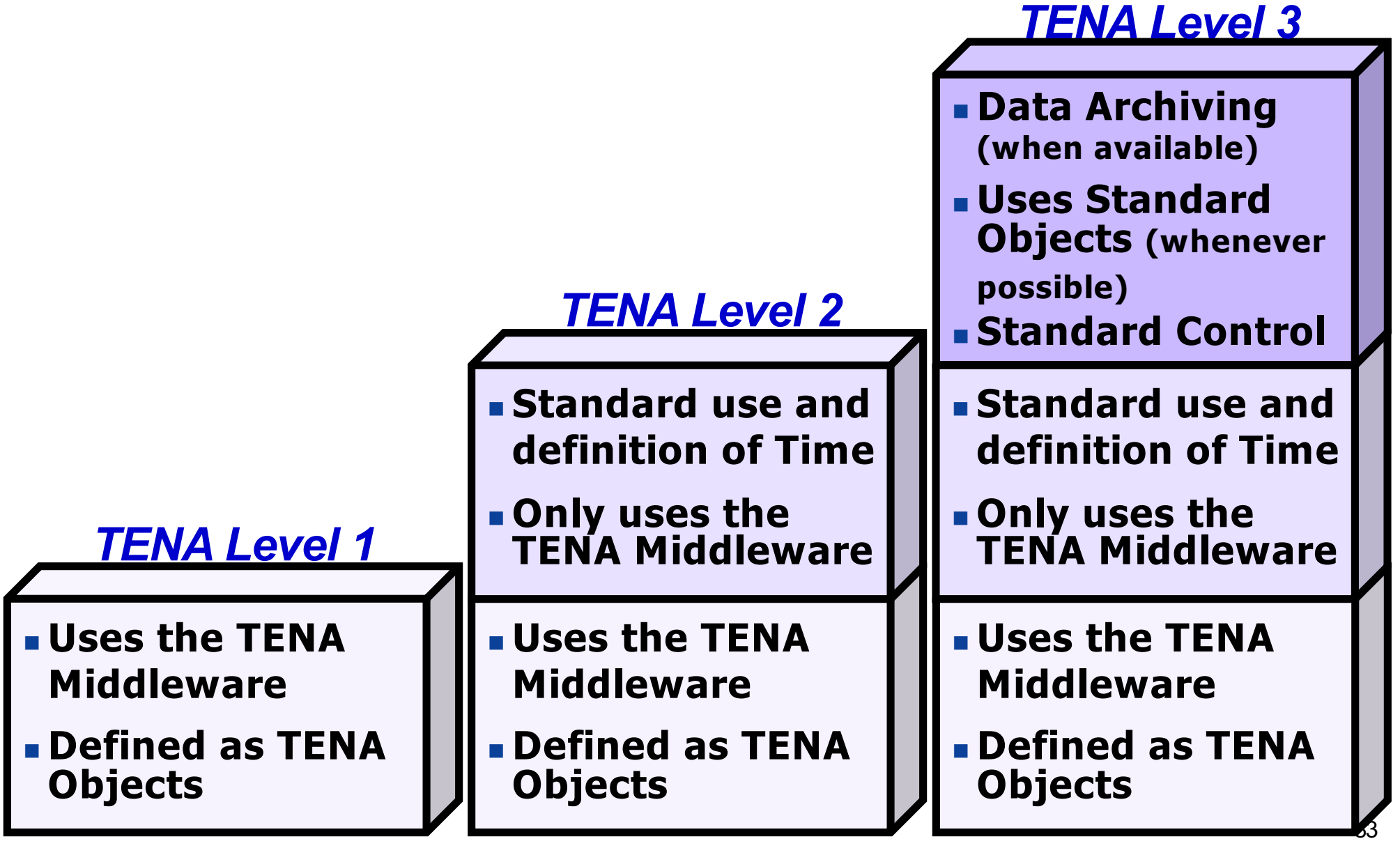
Technical Driving Requirements

1. **Interoperability**
   - The characteristic of a suite of independently-developed components, applications, or systems that implies that they can work together, as part of some business process, to achieve the goals defined by a user or users
2. **Reusability**
   - The characteristic of a given component, application, or system that implies that it can be used in arrangements, configurations, or in enterprises beyond those for which it was originally designed
3. **Composability**
   - The ability to rapidly assemble, initialize, test, and execute a system from members of a pool of reusable, interoperable elements
   - Composability can occur at any scale—reusable components can be combined to create an application, reusable applications can be combined to create a system, and reusable systems can be combined to create an enterprise

Achieving Interoperability and Reuse

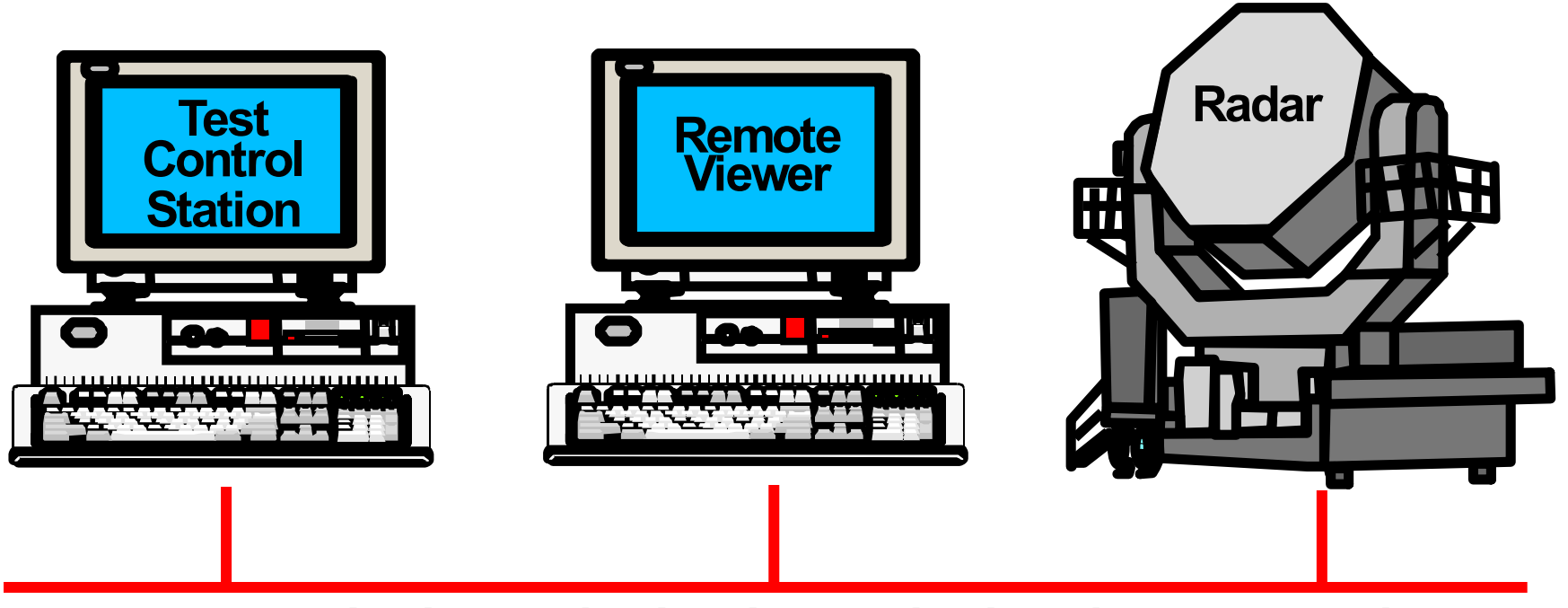
- **Interoperability requires**
  - A common architecture → **TENA**
  - An ability to meaningfully communicate
    - A common language → **TENA Object Model (OM)**
    - A common communication mechanism → **TENA Middleware, LRDA**
  - A common context
    - A common understanding of the environment → **SEDRIS (as part of the TENA OM)**
    - A common understanding of time → **TENA OM, Middleware**
    - A common technical process → **TENA Technical Process**
- **Reuse and Composability require the above, plus**
  - Well defined interfaces and functionality for the application to be reused → **Reusable Tools, Repository**
  - Place to store reusable components → **Repository**

TENA Compliancy Levels



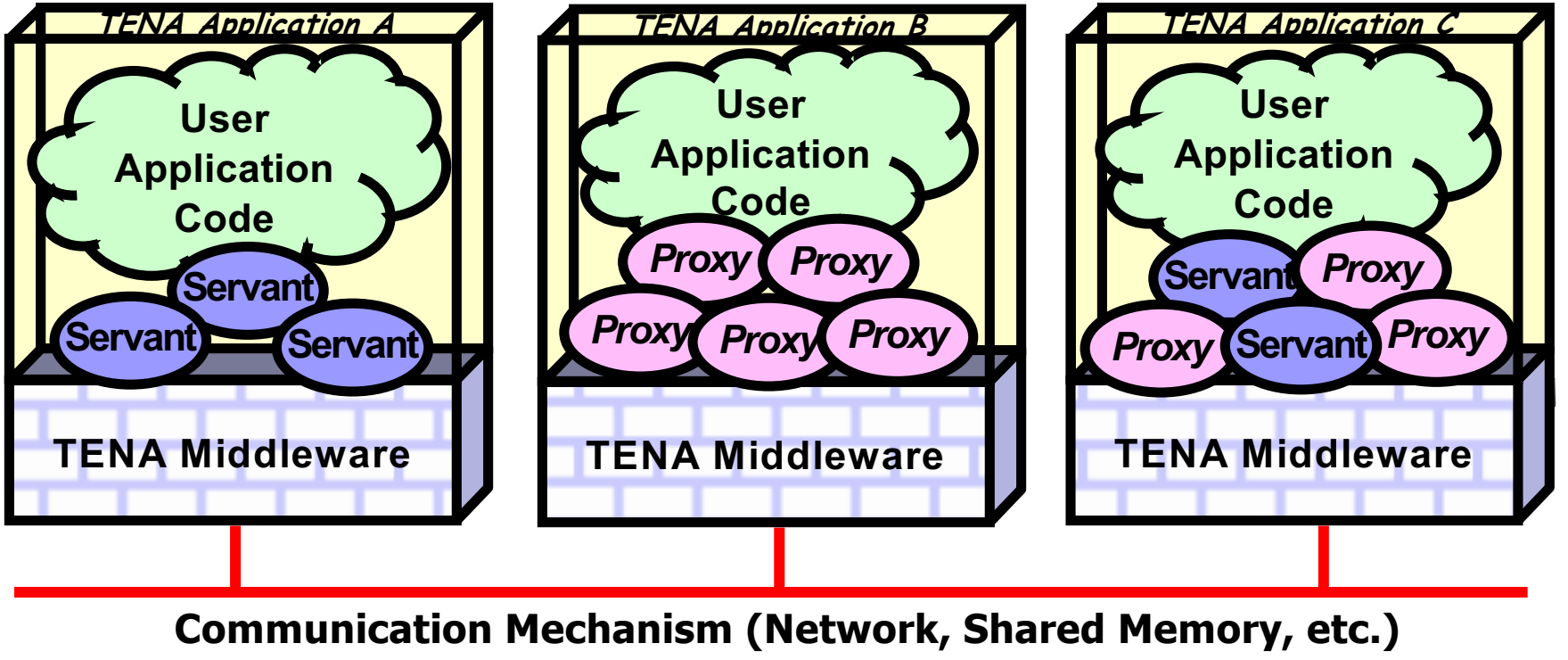
Logical Range Simple Example

TENA specifies an architecture for range resources participating in logical ranges



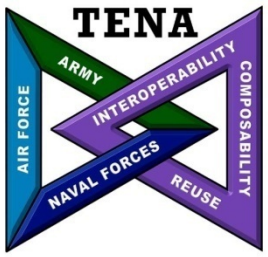
Logical Range Simple Example

- TENA specifies a peer-to-peer architecture for logical ranges:
  - Applications can be both clients and servers simultaneously
  - In their role as servers, applications serve TENA objects called "servants"
  - In their role as clients, applications obtain "proxies," representing other applications' servants. Only servers can write to their servant objects' publication state
- The TENA Middleware, the TENA objects, and the user's application code are compiled and linked together



What is a Meta-Model, and Why is it Important?

- **What is a Meta-Model?**
  - A meta-model is “a model that defines an abstract language for expressing other models,” from Common Warehouse Metamodel specification by Dr. Daniel T. Chang.
  - All computer languages have meta-models
  - The TENA Meta-Model describes the features of objects defined in a logical range object model (LROM)
- **Why is it important?**
  - The TENA Meta-Model is the architectural construct that specifies both the rules for defining an LROM and the requirements for the middleware

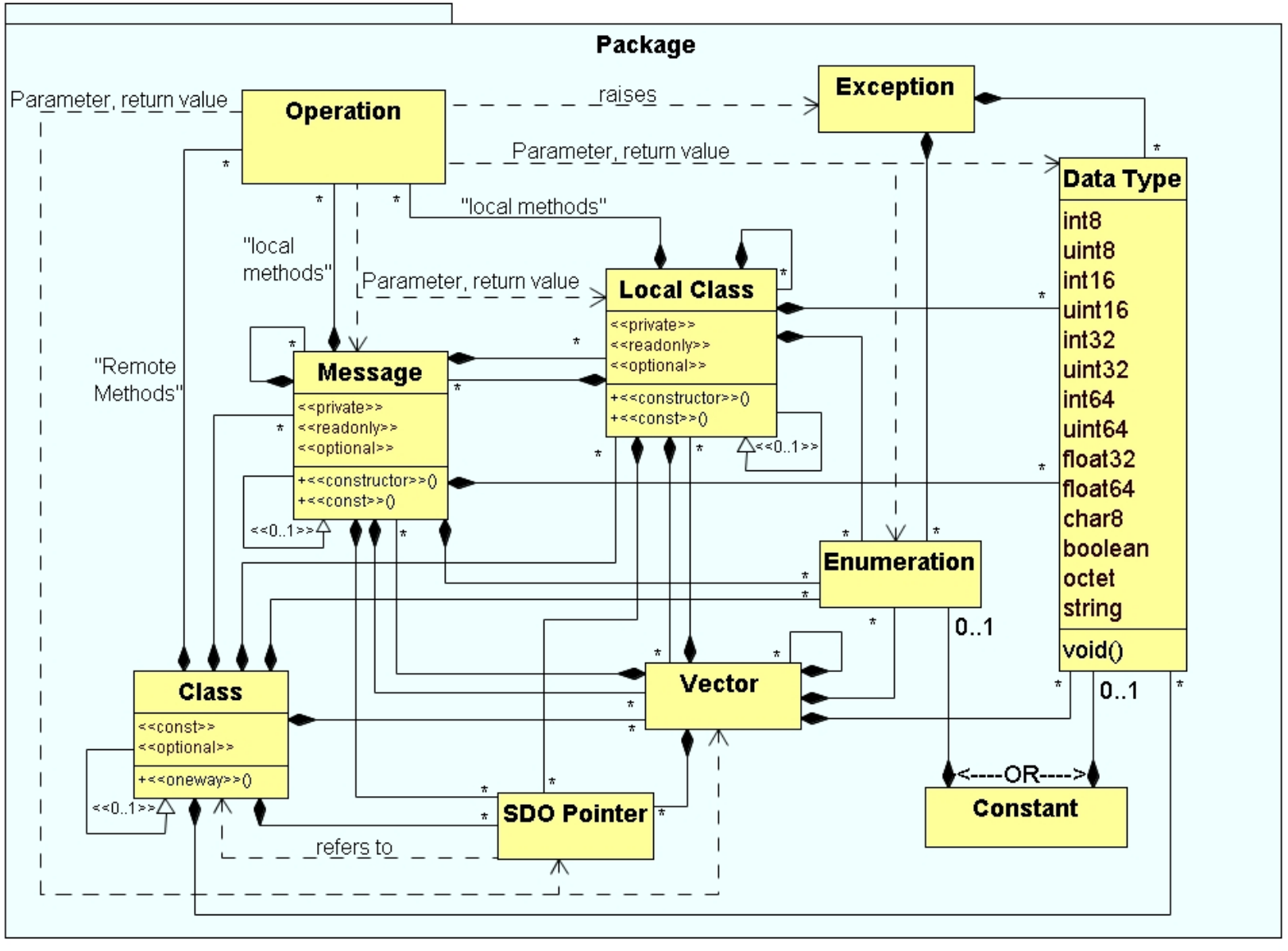


Requirements for Defining the TENA Meta-Model

- **Must support distributed computing**
- **Must be rich enough in features to support the object modeling needs of the entire test and training range community**
  - Objects and Messages
- **Must provide a semantic unification of information amenable to the creation of a simple, yet powerful, standard TENA Object Model**
- **Must be as easy to use and understand as possible given the above requirements**

These requirements led to the invention of the Stateful Distributed Object, combining the best features of CORBA and the HLA in one easy-to-use concept

TENA Meta-Model Release 6



Stateful Distributed Objects (SDOs)

- **An SDO is a combination of two powerful concepts:**
  - a distributed object paradigm (like the one used in CORBA)
  - a distributed publish and subscribe paradigm
- **Benefits of this combination:**
  - A conventional distributed object-oriented system offers no direct support to the user for disseminating data from a single source to multiple destinations
  - A conventional publish-subscribe system does not provide the abstraction of objects with a set of methods in their interface
  - Interface to SDOs is a lot simpler and more usable than the combination of interfaces to their underlying technologies

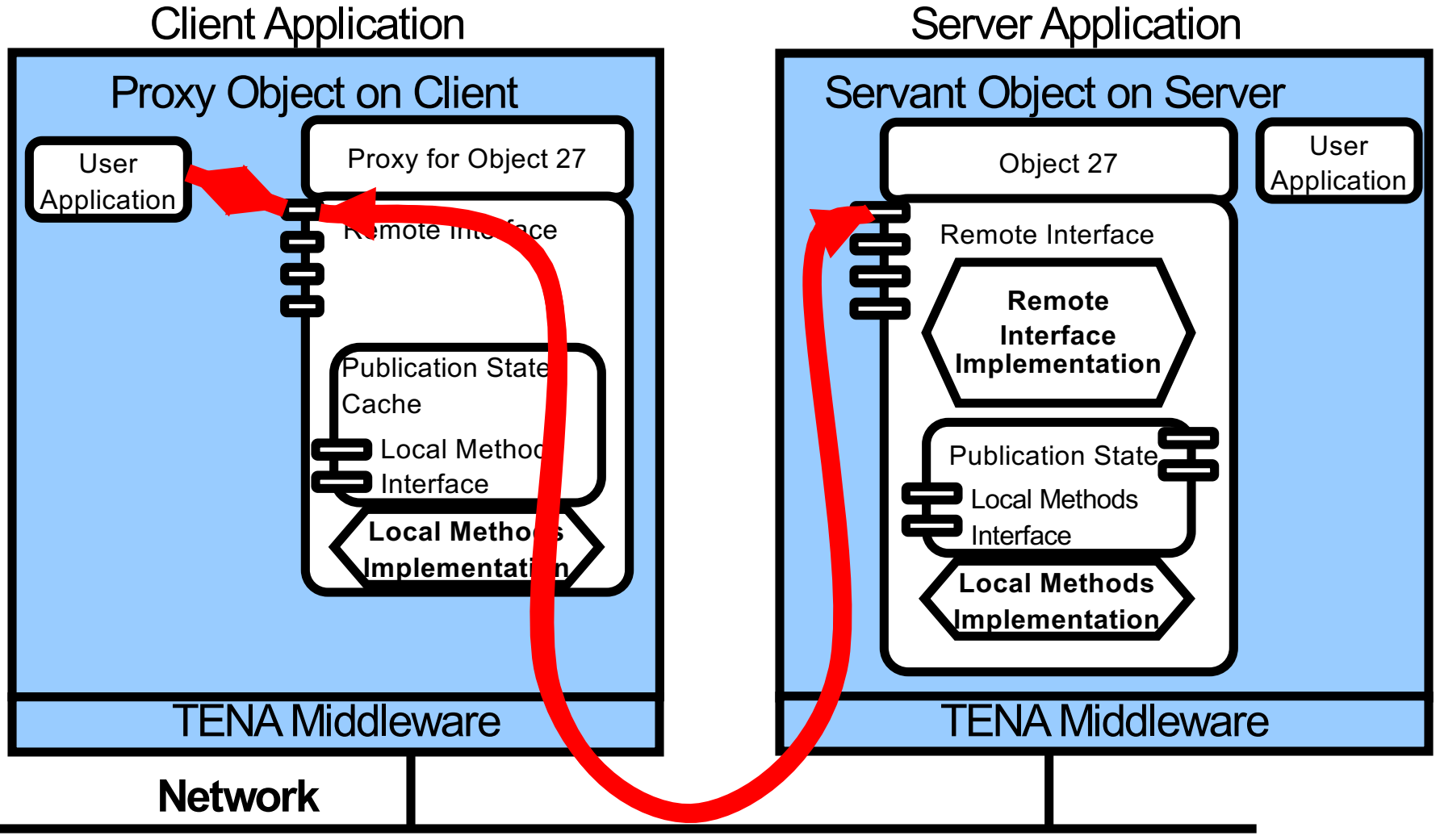
The Ways in Which TENA Applications Can Communicate

TENA provides to the application developer a unification of several powerful inter-application communication paradigms:

- **Publish/Subscribe**
  - Each application publishes certain types of information to which any other application can subscribe
  - Similar in effect to HLA, DIS, CORBA Event Service, DDS, etc.
- **Remote Method Invocation (RMI)**
  - Each object that is published may have methods that can be remotely invoked by other applications
  - Similar to CORBA RMI or Java RMI
- **Distributed Shared Memory (DSM)**
  - Applications read and write the state of objects as if they were local objects, even though they are remote objects
  - A very natural, easy to understand programming paradigm that projects the illusion of working on a shared memory multi-processor machine onto a distributed computing system
- **Messages**
  - Individual messages that can be sent from one application to other applications

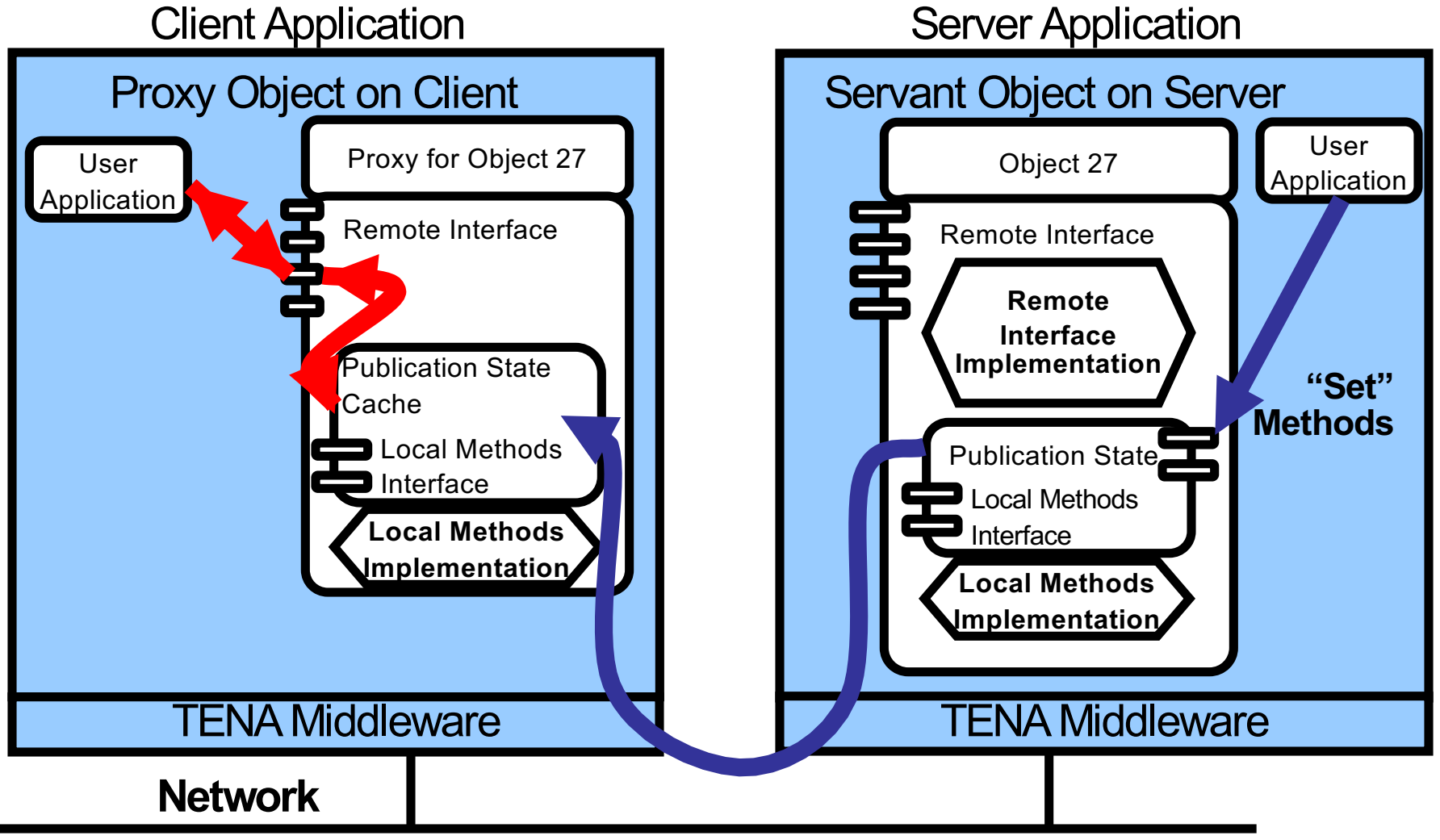
Clients and Proxies, Servers and Servants

- **Remote Method Invocation**



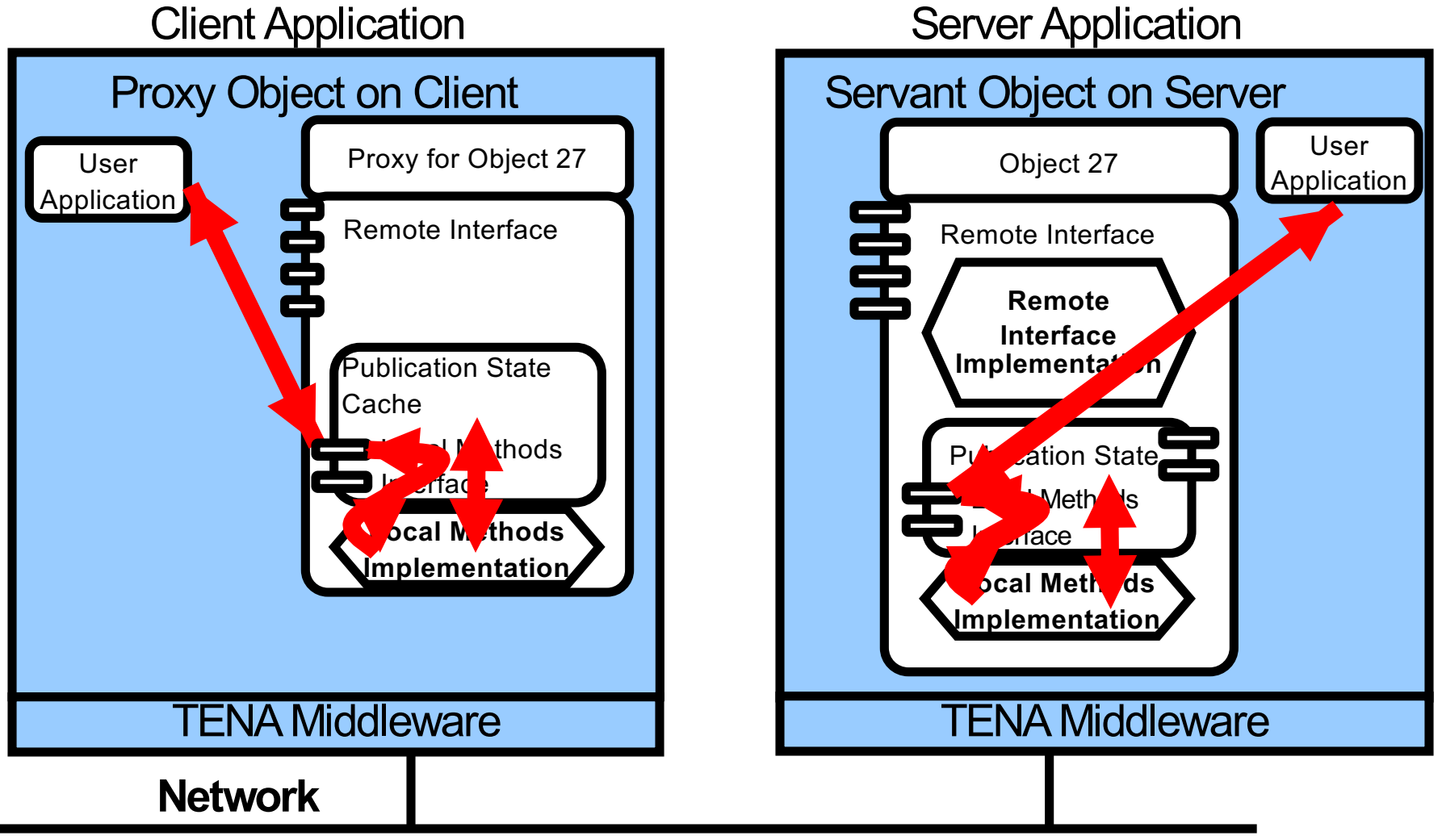
Clients and Proxies, Servers and Servants

- **Publication State Dissemination and Access**



Clients and Proxies, Servers and Servants

- **Local Methods used on both Client and Server**



TENA Objects are Compiled In

- **Why use compiled-in object definitions?**
  - **Strong type-checking**
    - Don't wait until runtime to find errors that a compiler could detect
  - **Performance**
    - Interpretation of methods/attributes has significant impact
  - Ability to easily handle complex object relationships
  - Conforms to current best software engineering practices
- **How do you support compiled-in object definitions?**
  - Use a language like CORBA Interface Definition Language (IDL) to define object interface and object state structure
  - Use **code generation** to implement the required functionality
- **Thus the concept of the TENA Definition Language (TDL) was created**
  - Very similar to IDL and C++

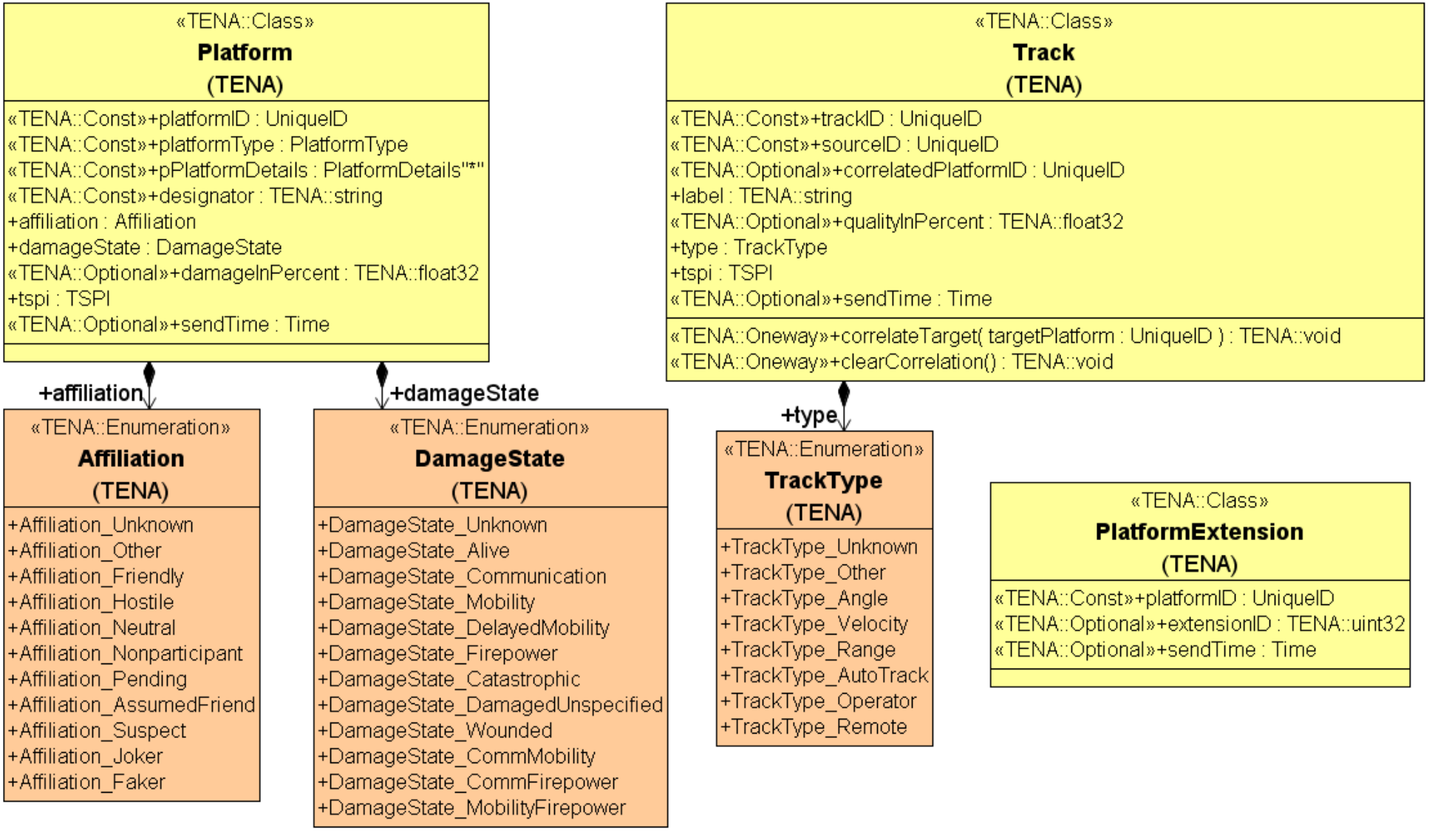
TENA Object Models

- **Enable semantic interoperability among range resource applications**
- **Provide the "common language" that all range resource applications use to communicate**
- **Object Model Stages**
  - **User-Defined Objects** – objects defined solely for the purpose of a given logical range by TENA users
  - **TENA Candidate Objects** – objects defined as potential standards, which are undergoing test and evaluation by the community prior to standardization
  - **TENA Standard Objects** – objects developed and supported by the TENA SDA, which have been approved for standardization by the AMT

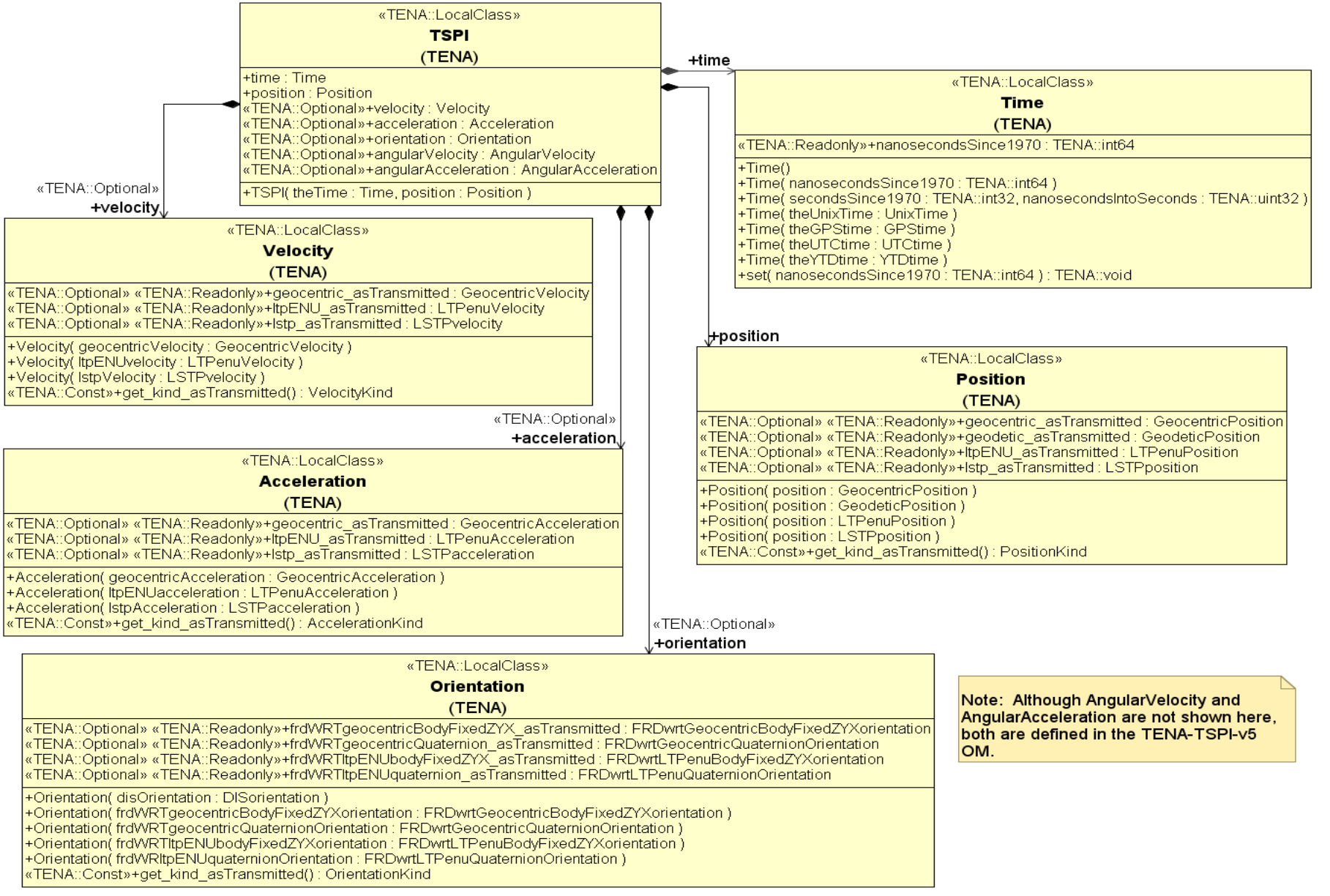
Standard Interface Definitions

- **JMETC uses standard TENA Object Models to define a standardized interface between test platforms.**
  - Current Object Models:
    - TENA TSPI
    - TENA Platform
    - TENA Munition
    - TENA Time
    - TENA AMO
    - Radar Object
    - GPS-Based System Object
    - TENA Engagement
    - TENA Pointing
  - Future Object Models:
    - Radar Track
    - TENA Measurand
    - TENA Weather Server
    - Tactical Message Sets
    - Time Management
    - Middleware Management

TENA-Platform-v4

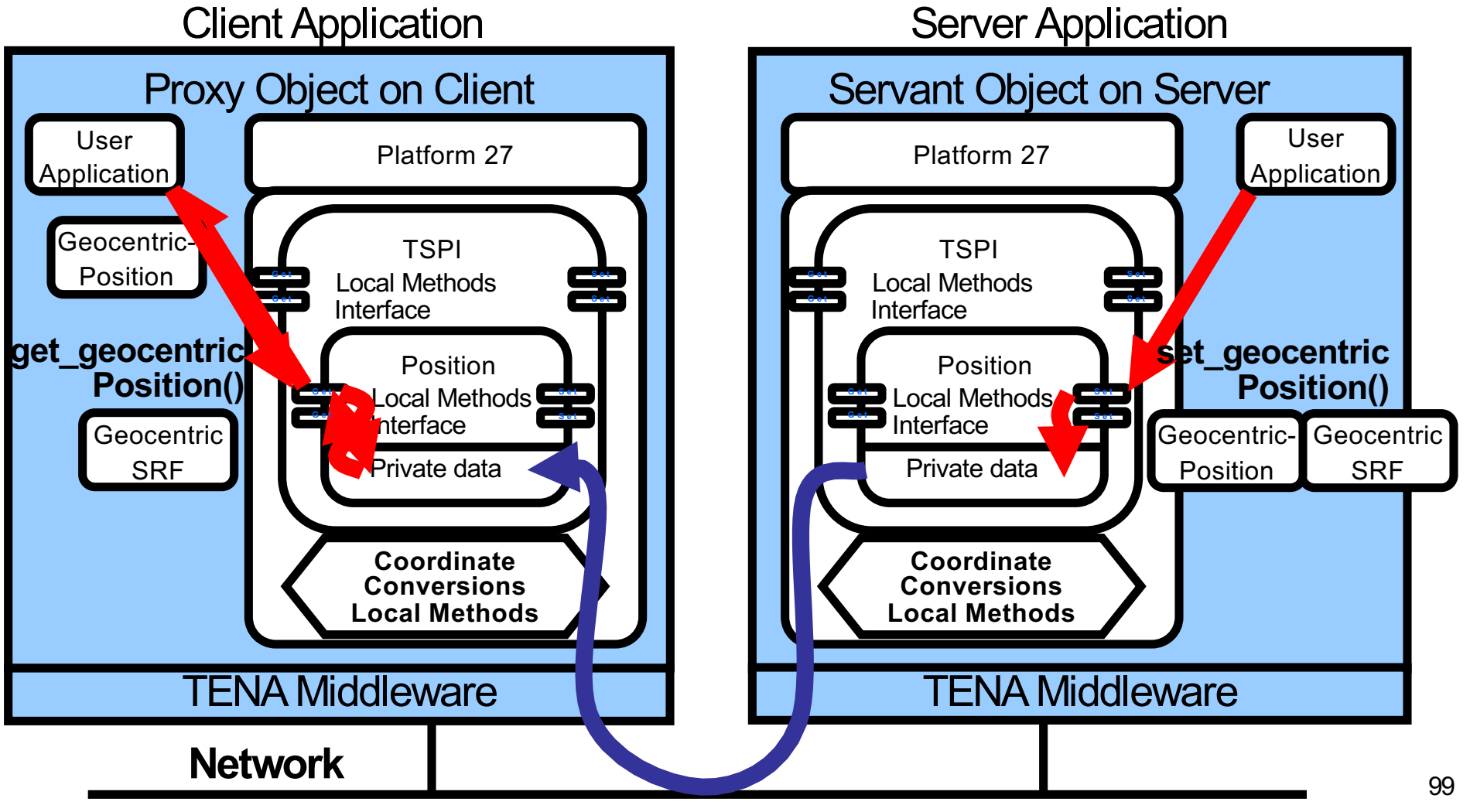


TENA-TSPI-v5
(TENA Standard)



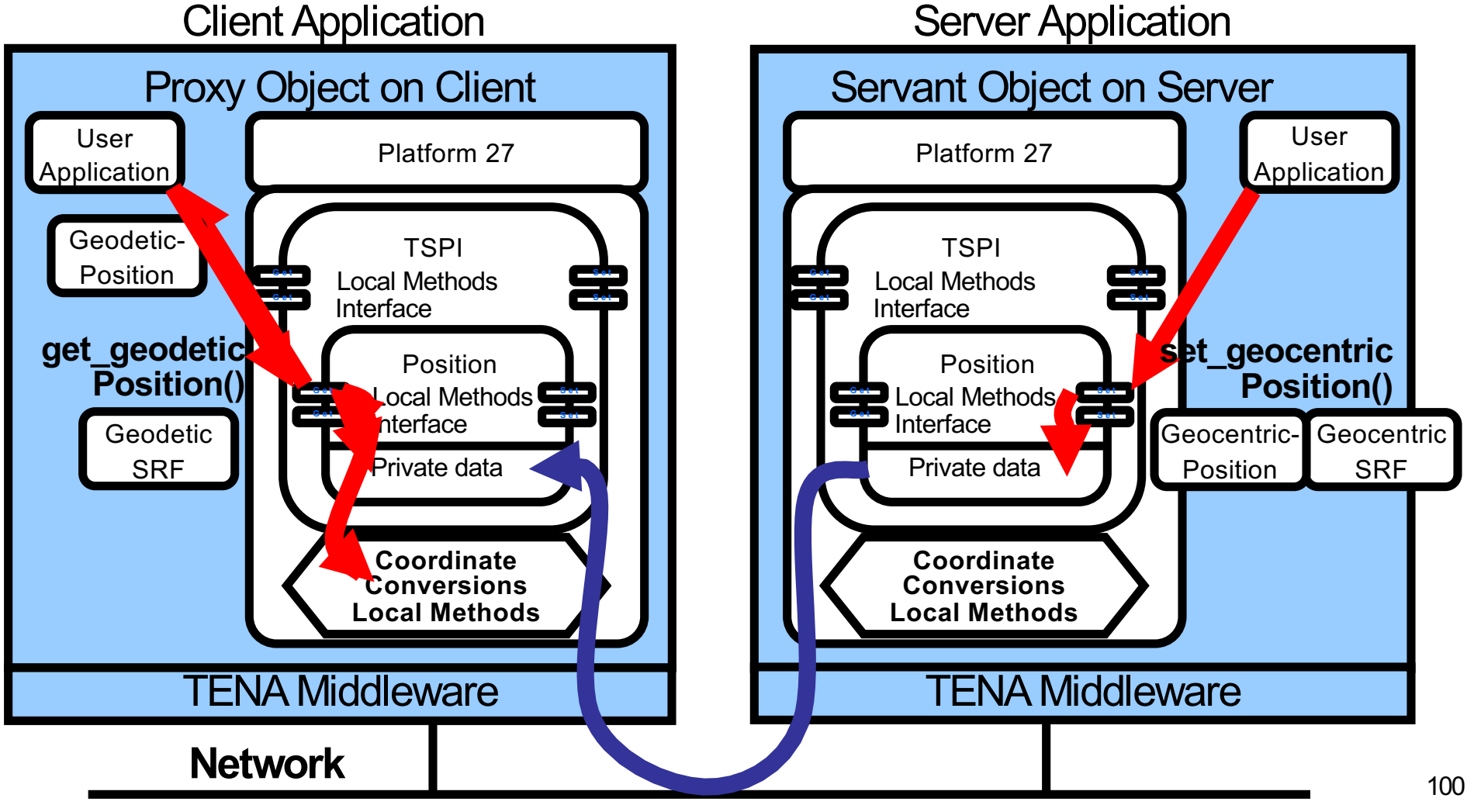
TSPI with Coordinate Conversions

- **Case 1: Reading and writing in the same coordinate system**



TSPI with Coordinate Conversions

- **Case 2: Reading and writing in different coordinate systems**
  - Write in Geocentric (ECEF), read in Geodetic (latitude/longitude/altitude)



TENA Common Infrastructure

- **Components:**
  - Repository
  - Logical Range Data Archive
  - Middleware
- **Purpose:**
  - Provide the common, standardized, software mechanism that makes communication about objects in the TENA Object Model as efficient and simple as possible throughout the entire range event lifecycle

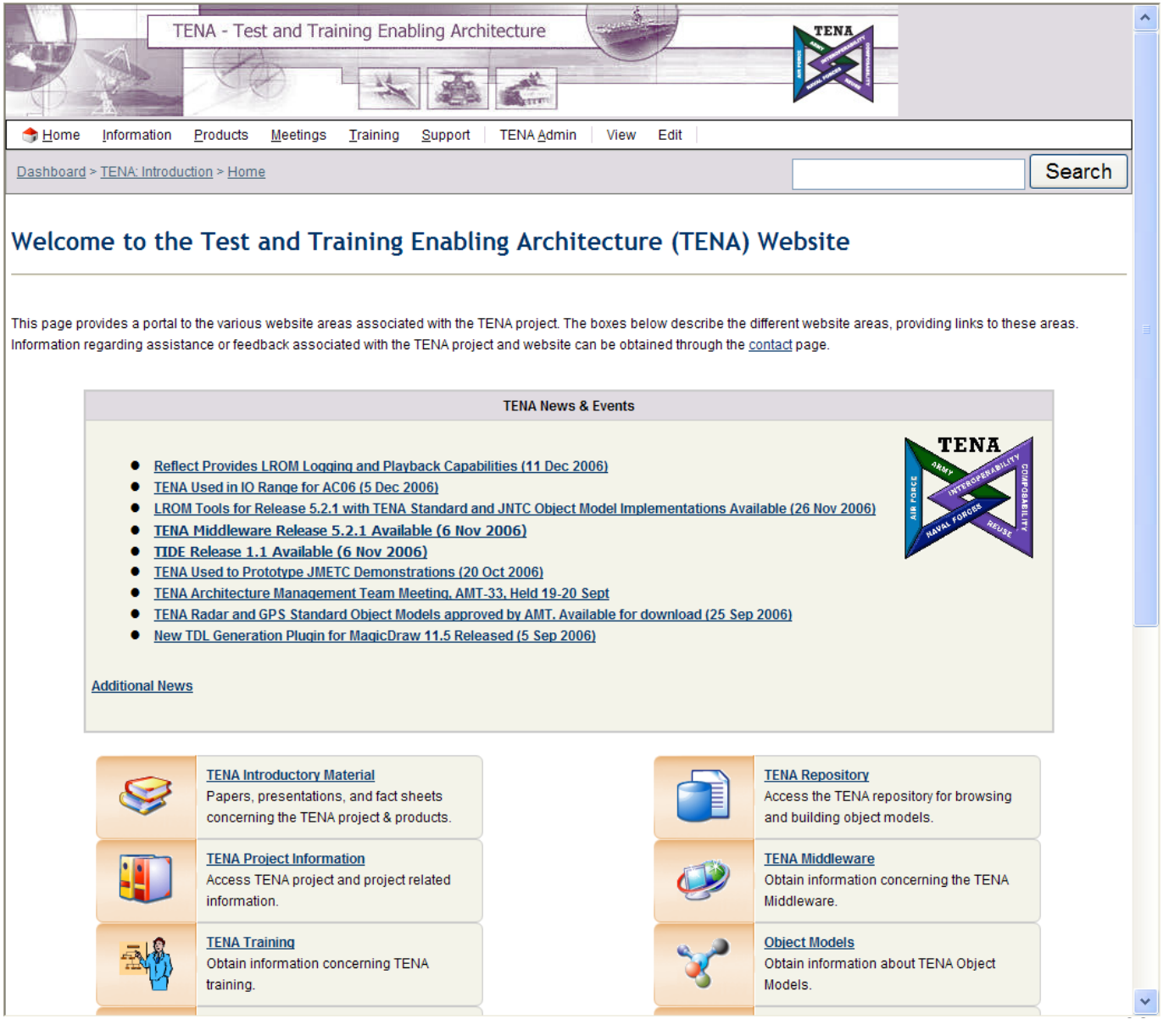
TENA Repository

- **Purpose: to contain all the information relevant to TENA that is not specific to a given logical range**
- **Current Repository Contents:**
  - All TENA Object Models, both standard and user-designed
  - All TENA software (middleware, helpdesk cases, tools, gateways, reusable applications, and reusable components)
  - All TENA documentation
  - Lessons learned from previous uses of TENA
  - Provide an easy-to-use secure interface to all of this information
- **The Repository is a collection of technologies based around a wiki-like front end**

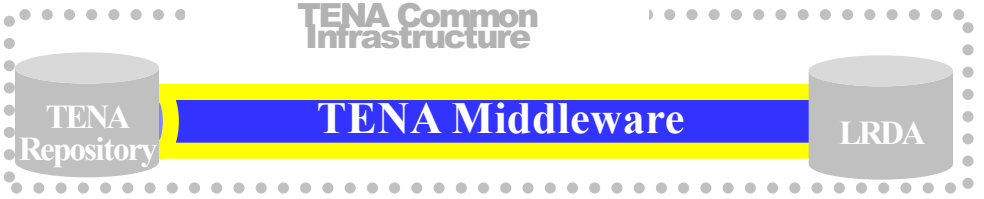
TENA Web Portal
http://www.tena-sda.org/

- **Registered user account required**

- **Contains**
  - News
  - Meeting Notices
  - Documentation
  - Middleware
  - Object Models
  - Training Materials



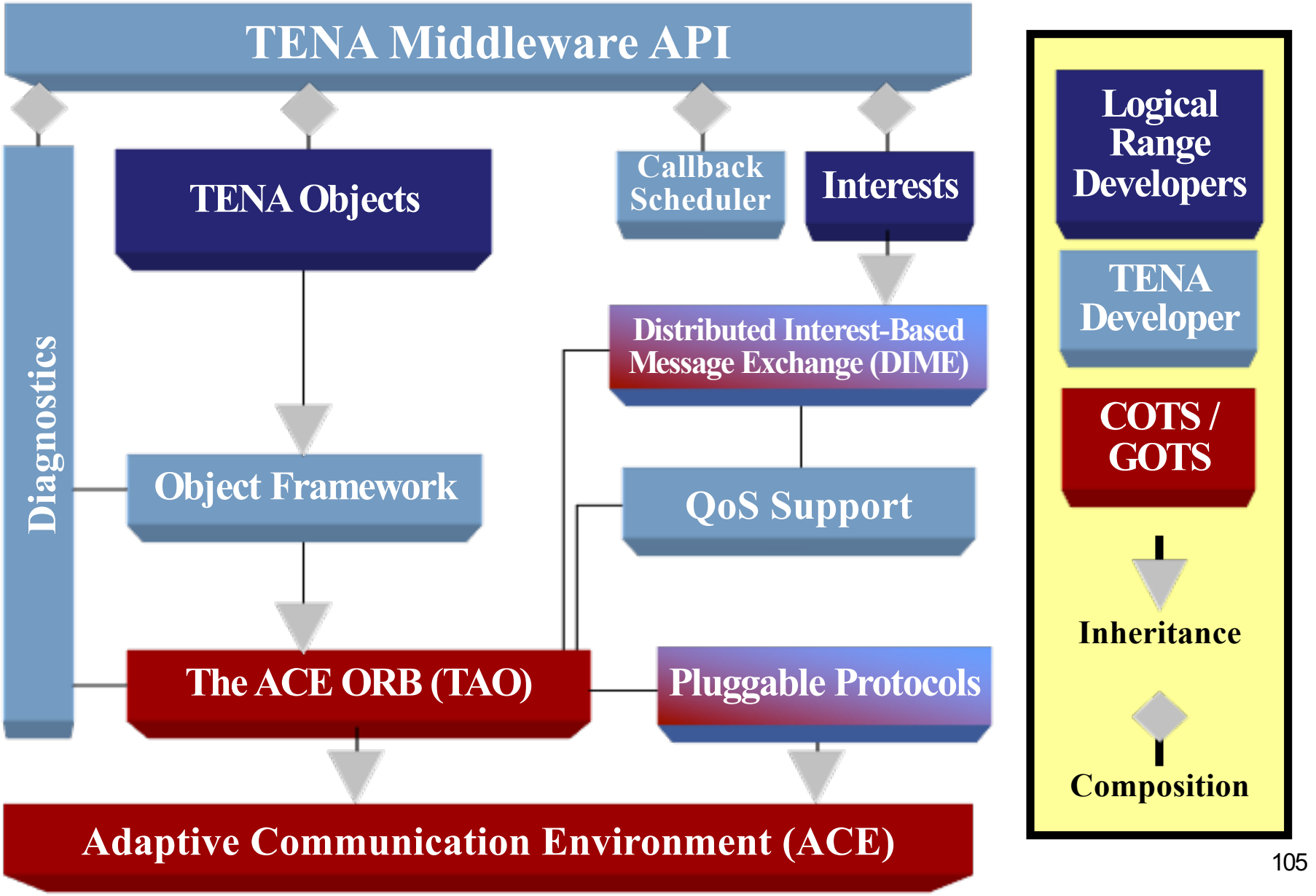
TENA Middleware Purpose and Requirements



- **Purpose: high-performance, real-time, low-latency communication infrastructure used by range resource applications and tools during execution**
- **Requirements:**
  - Fully support TENA Meta-Model
  - Be easy to use and highly reliable
  - Many varied communication strategies and media
    - Including management of quality-of-service
    - Including object-level security services
  - Be high-performance, including
    - Support multiple information filtering strategies
    - Support user-defined filtering criteria
  - Support a wide variety of range-relevant platforms (hardware/operating system/compiler)
  - Be technology neutral

Middleware Release 6 available for Download

TENA Middleware Current Design Overview



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- Local Methods Factory Registration
- Code Installation Layout

Example - Object Reactivation

- **The capability to restore an SDO servant after a crash, such that subscribing applications consider updates to apply to the existing proxy they hold**
- **Notionally:**

```
// Before crash
std::string filename = "C:Servant01.save"
pServant->save(filename)

// After crash
// Recreate the servant
std::auto_ptr<OMsample:Platform::ReactivationInitializer> rinit(
  pSF->createReactivationInitializer(filename) );
rinit->set_...  // reset the initial values
pServant = pSF->reactivateServant( pRemoteMethods, rinit );
```

- **This recreates the Servant with identical SDO ID as before.**

Example - Advanced Filtering

- **SDOs and Messages can now be assigned an integer "tag"**
- **Users can decide what these integer tags mean**
- **Subscribers can now subscribe to type/tag combinations**
  - Subscribe to all Platforms –OR–
  - Subscribe to Platforms with tag 1
- **Assign an initial tag:**

```
unsigned long tag = 1;
pPlatformServant = pServantFactory->
  createServantUsingDefaultFactory( *initializer,
    DIME::Interest::Metadata(tag), communicationProperties );
```

- **API for changing tags on servant not set yet**
- **Subscribe to SDO with a tag:**

```
unsigned long tag = 1;
pSession->subscribeToSDO< OMsample::Platform::ProxyTraits >(
  pPlatformStrategy,
    DIME::Interest::Metadata(tag) );
```

Release 6 Platform Support

- Linux Fedora Core 6
- Linux Fedora Core 6, 64-bit
- Linux Fedora 12
- Linux Fedora 12, 64-bit
- Linux Red Hat Enterprise Workstation 4
- Linux Red Hat Enterprise Workstation 4, 64-bit
- Linux Red Hat Enterprise Linux 5.2
- Linux Red Hat Enterprise Linux 5.2, 64-bit
- Linux openSUSE 11.latest
- MAC OS X 10.6, Snow Leopard (Intel 64-bit)
- Windows XP, Visual Studio 2005
- Windows Server 2003, 64-bit, Visual Studio 2005
- Windows XP, Visual Studio 2008
- Windows Vista, Visual Studio 2008

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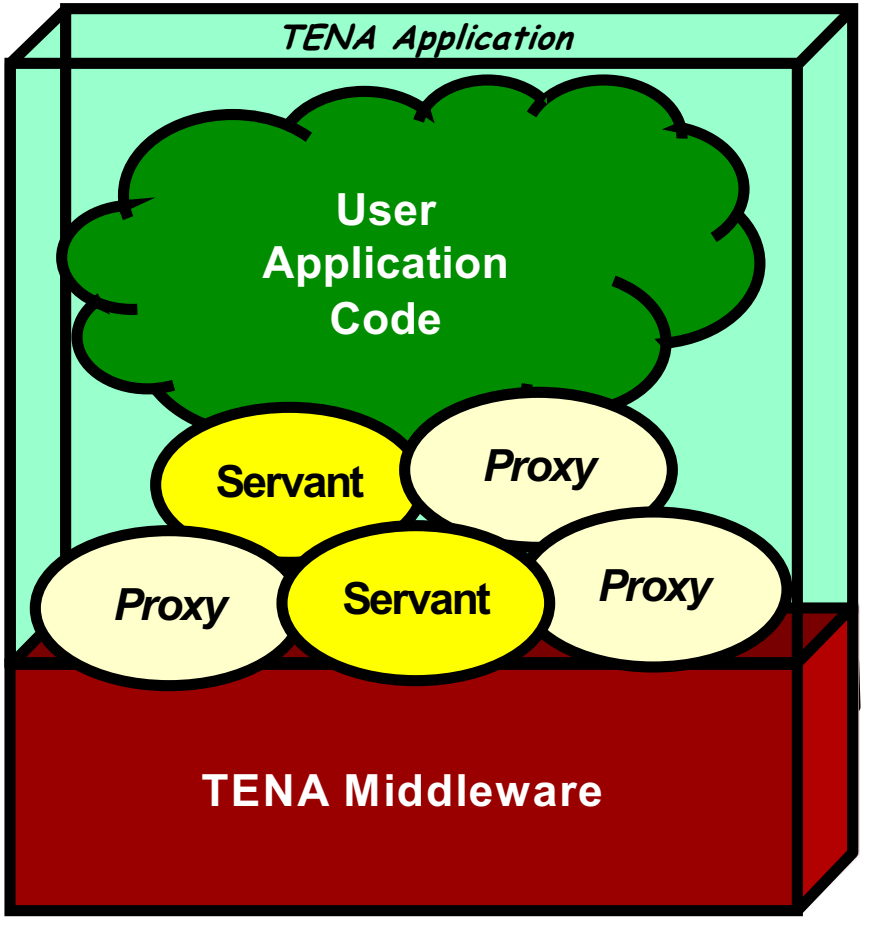
TENA Application Architecture

- **Purpose:** Explains how applications should be built
- Emphasizes that the middleware and the LROM are linked into the application

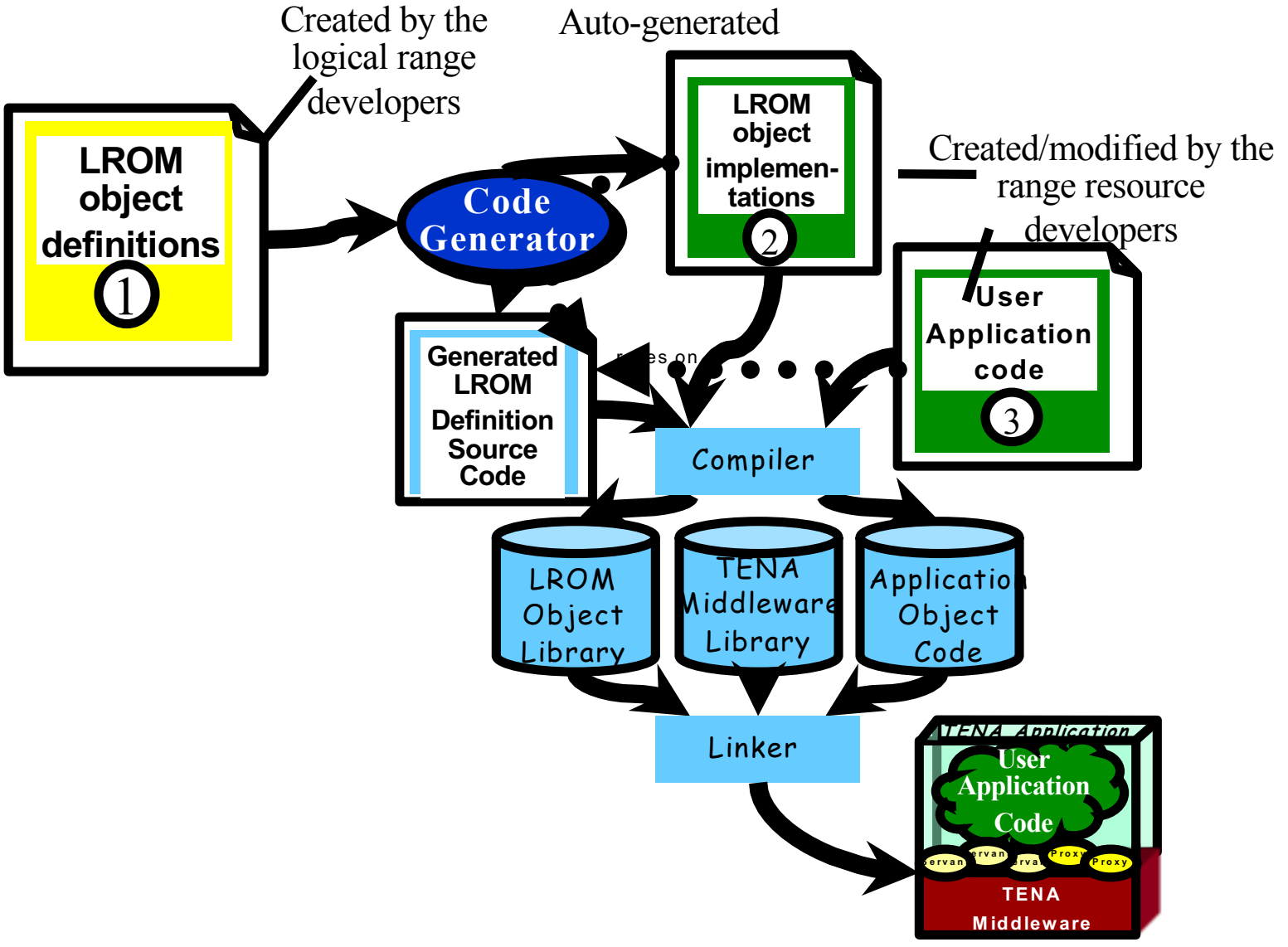
APPLICATION CODE:
Specific to an individual application

OBJECT MODEL CODE:
Common across a given logical range

TENA CODE:
Common across all TENA applications

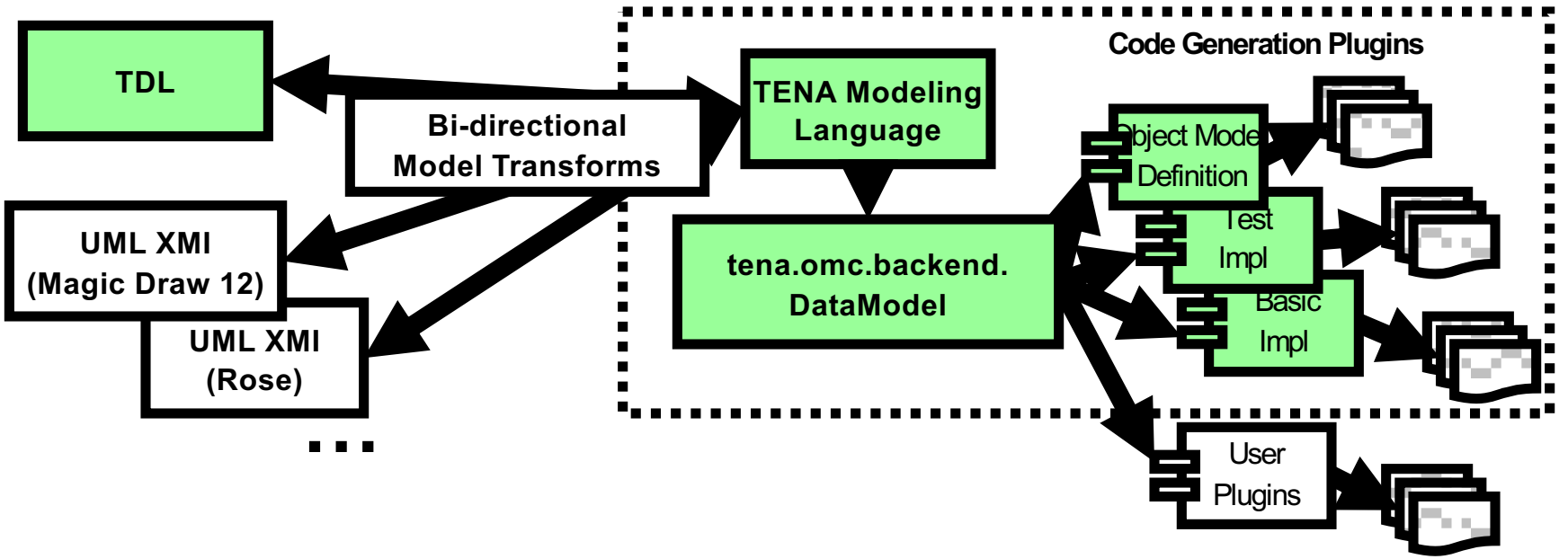


Creating a TENA Application



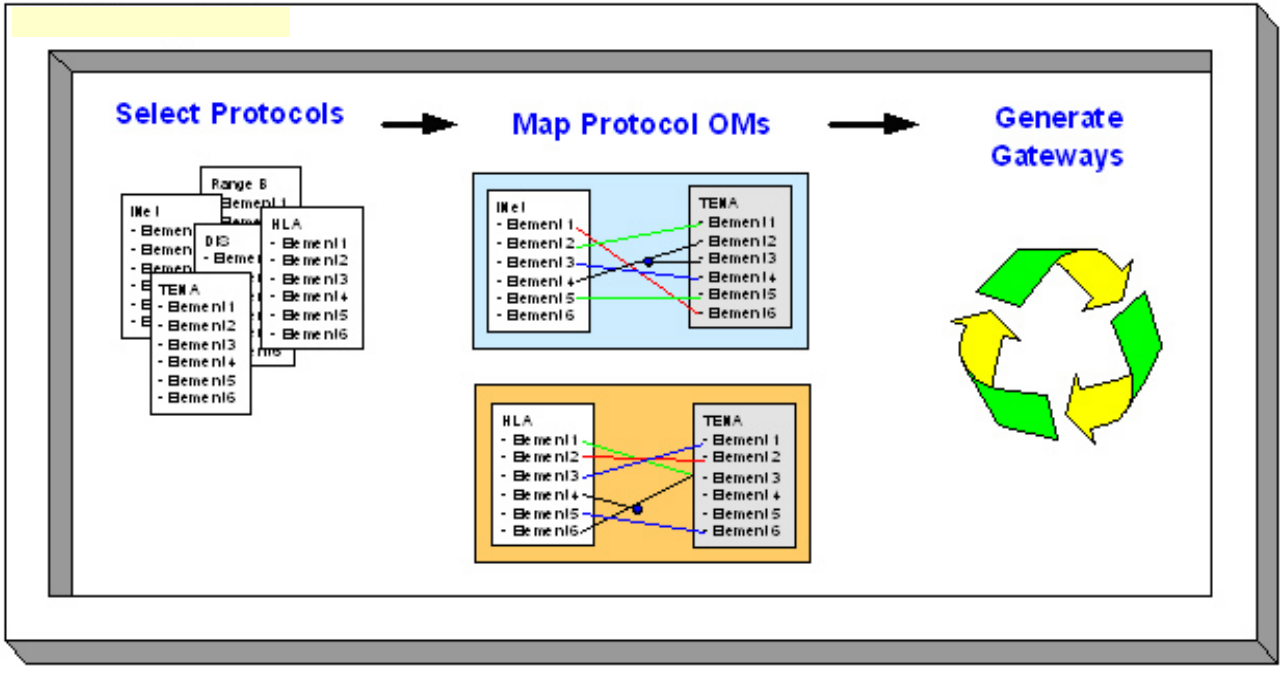
Auto-Code Generation With TENA

- **Our desire is for the input to the TENA auto-code generator be standard XMI (generated from UML)**
- **Challenges: XMI not yet implemented in a standard way by tool vendors, and current auto-code generation capability is based on TDL**
- **Current Interim Solution – Use MagicDraw plug-in to create TDL from UML**
- **Next Steps**
  - Implement TENA Metamodel in Eclipse Modeling Framework using ECore representation – define TENA Modeling Language (TML)
  - Create XMI ↔ TML, TDL ↔ TML translators
  - API and framework being developed to support various "code generation plugins" used to automatically create specialized code based on FreeMarker templates



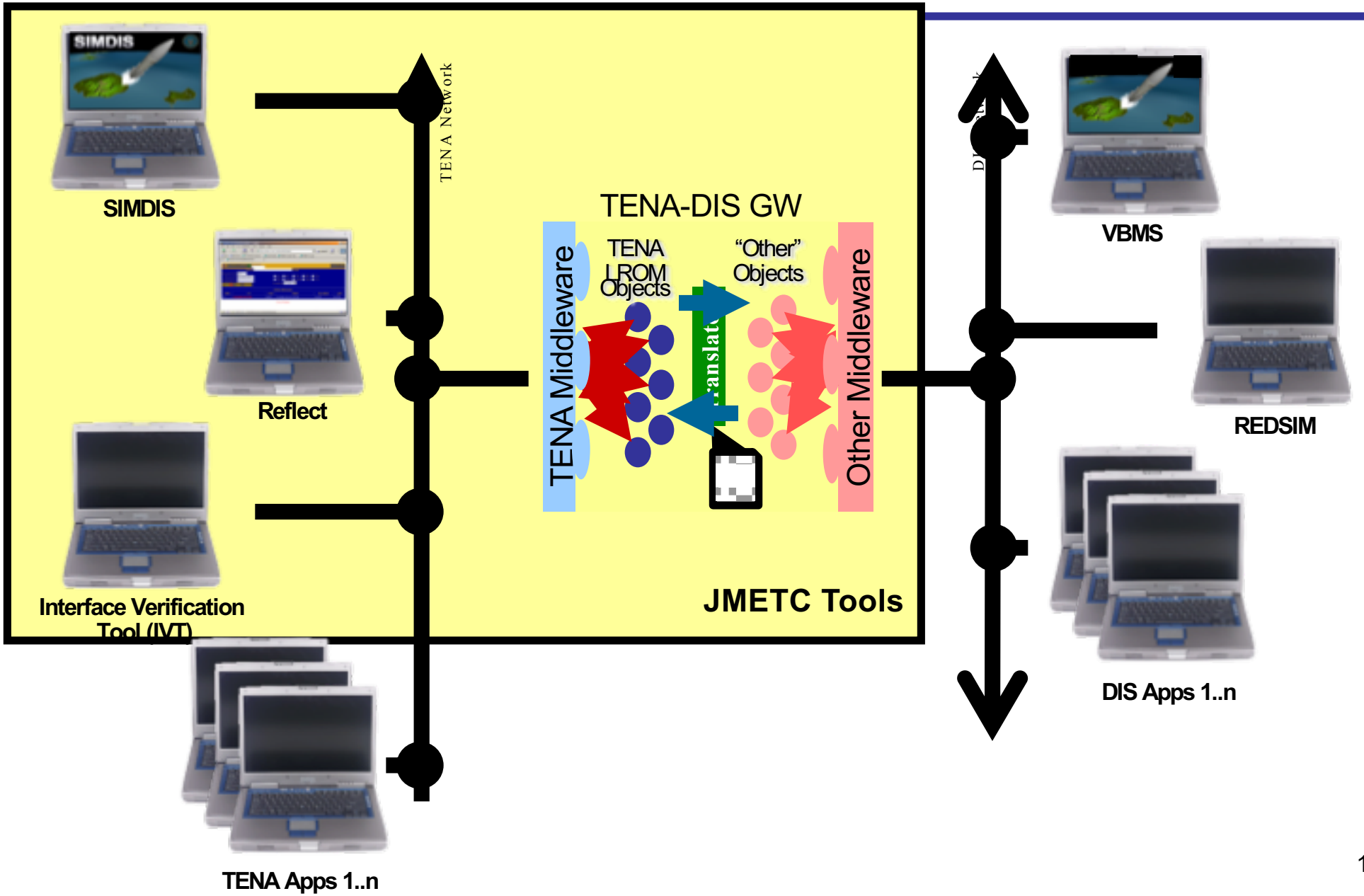
Gateway Builder

- MSR Program is focused on integration of distributed live, virtual, and constructive (LVC) systems into a common synthetic battle space that comprises various simulation protocols, training ranges, live systems and platforms
- Gateway Builder streamlines integration process and reduces time and effort of creating gateways
- Gateway Builder is a flexible, extensible, graphically driven tool that automatically generates gateways to bridge simulation and live protocols
- Gateway Builder supports mappings between TENA, DIS, and HLA and message-based protocols using any object model

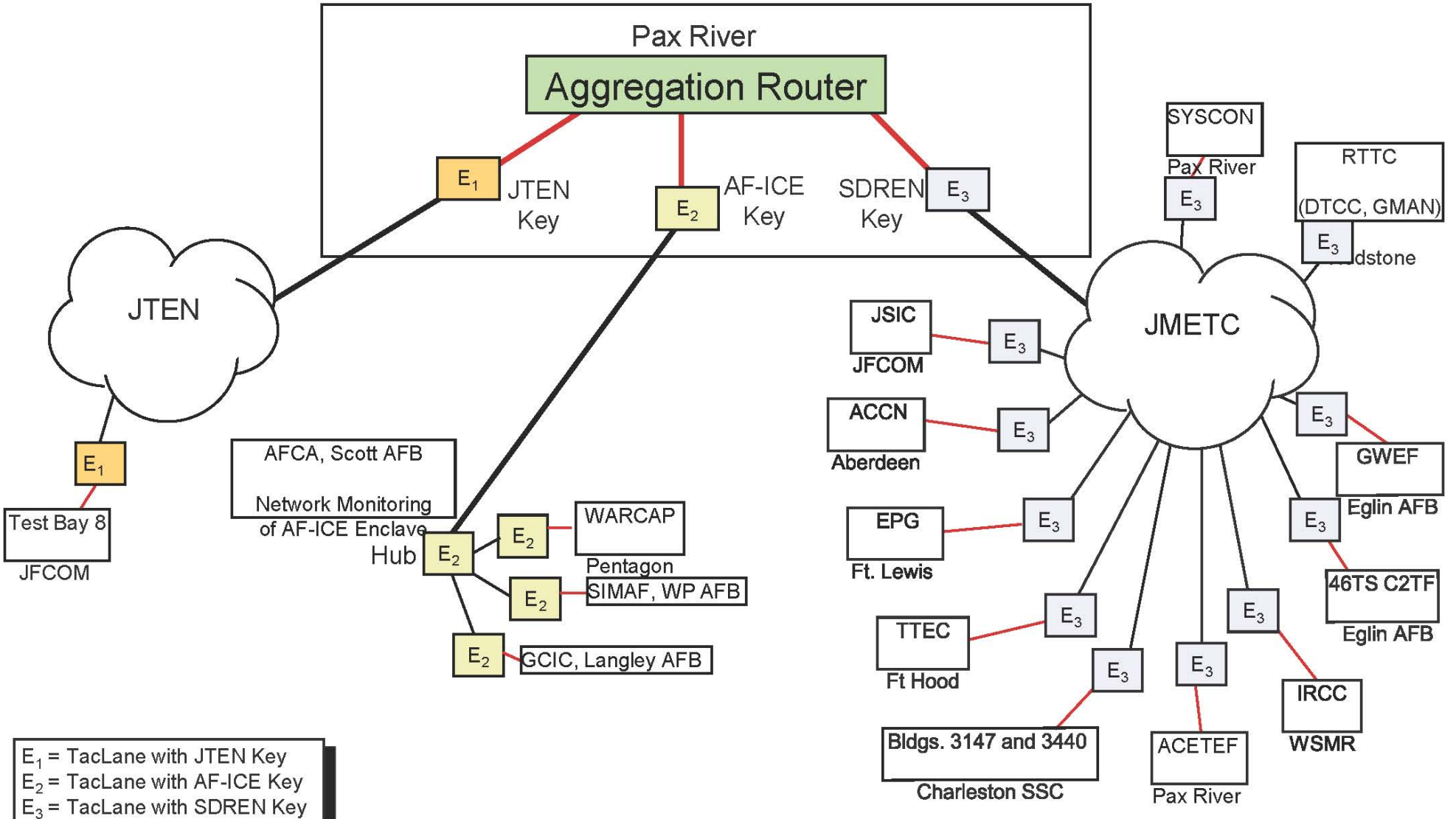


Gateway Builder Simplified Block Diagram

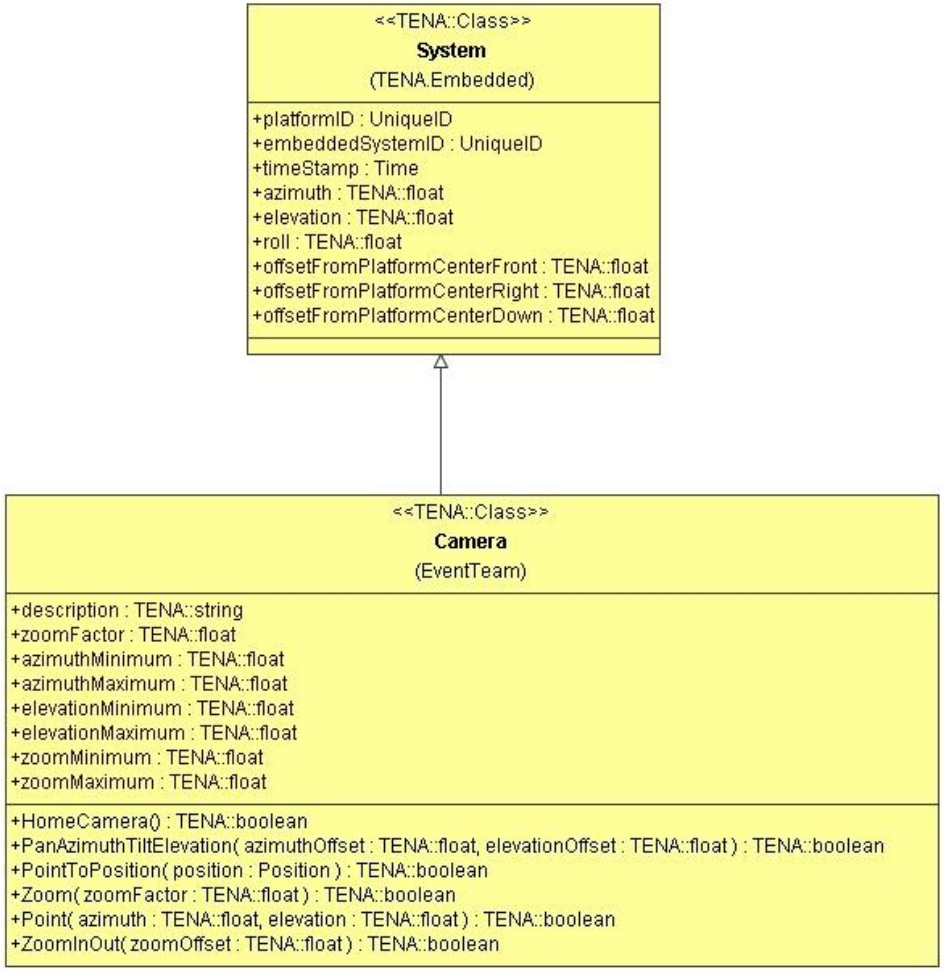
JMETC Tool Integration with Legacy Applications

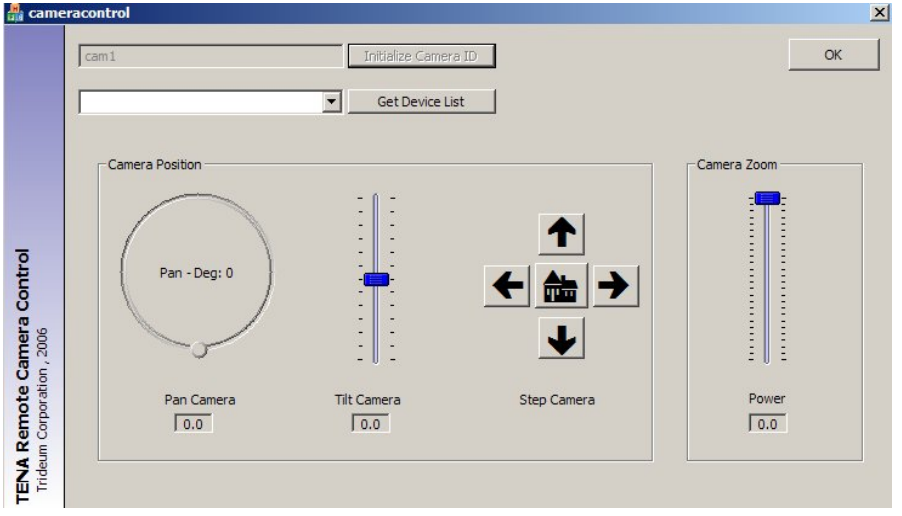


Gateway Builder (GWB) Fielding during JBD2



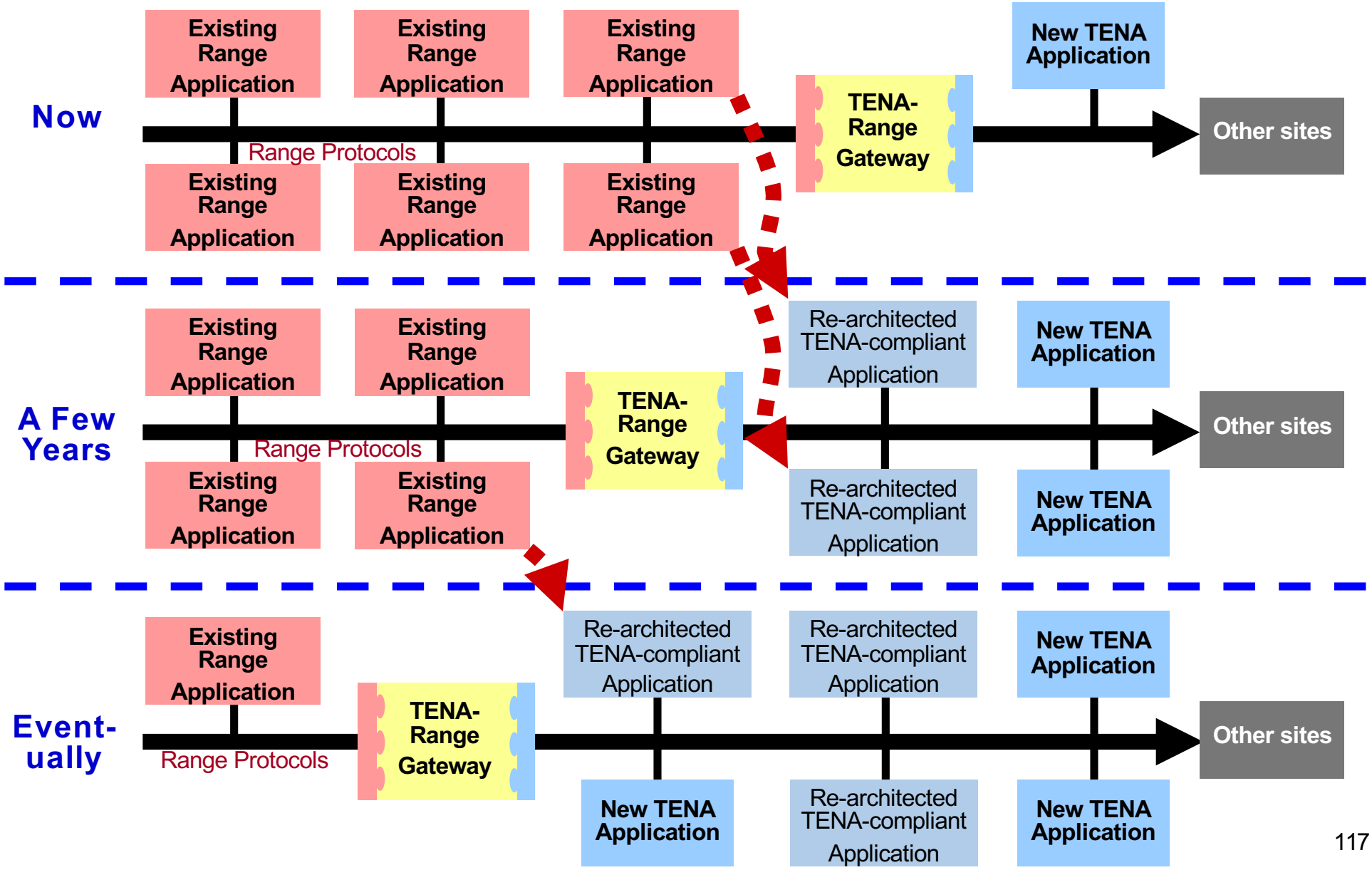
TENA Video Distribution System
Camera Object Model / Camera Control





Controls Pan-Tilt-Zoom (PTZ) Camera or Camera Platform

Gradual Deployment of TENA



TENA Upgrade Support Offer

- **The TENA team is available to offer advice and assist any organization looking to use TENA**
  - Advice on overall design approach and trade-offs to consider
  - Recommended Object Models to reuse
  - Recommendations on how to design new Object Models
  - Implementation / Code Designs Reviews
  - Awareness of similar systems and lessons learned
  - Hands-on training classes on TENA capabilities
  - Hands-on training classes on using "TIDE" (a TENA Development Tool)
    - Eases developing TENA interface
    - Assists incorporating different Object Models
    - Upgrade utility for HLA applications migrating to TENA

Opportunity to Get Assistance in Using TENA

E-mail request to: feedback@tena-sda.org

TENA in a Resource Constrained Environment (TRCE) S&T Background

- **Low Data Rate Networks**
  - TENA must be able to establish and maintain data connections on low data rate networks
  - Need to optimize use of low data rate networks to support relevant operational scenarios
- **Wireless Networks**
  - Current range environments use wireless links extensively for various systems under test
- **Variable Quality Networks**
  - T&E systems poorly tolerate high loss, link failure, or heterogeneous links
  - Need to provide data continuity for degraded or heterogeneous networks
- **Specification of Interests**
  - Subscribers must be able to specify data "interests" to more efficiently use available & limited network resources

TRCE Phase 1 will:

•Developed Use Cases and Requirements

•Developed Proof-of-Concept Applications to Investigate Candidate Technologies

•Quantified Benefits of Candidate Technologies

•Representative Laboratory Environment

•Successful Phase 1 Technology Demonstration

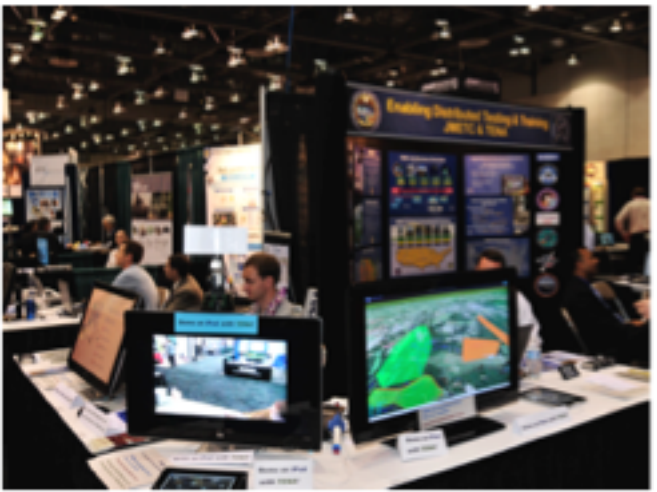
•Recommended Technologies for Further Development and Inclusion in the TENA Middleware

TRCE is providing TENA for variable quality and low data rate network links including wireless networks

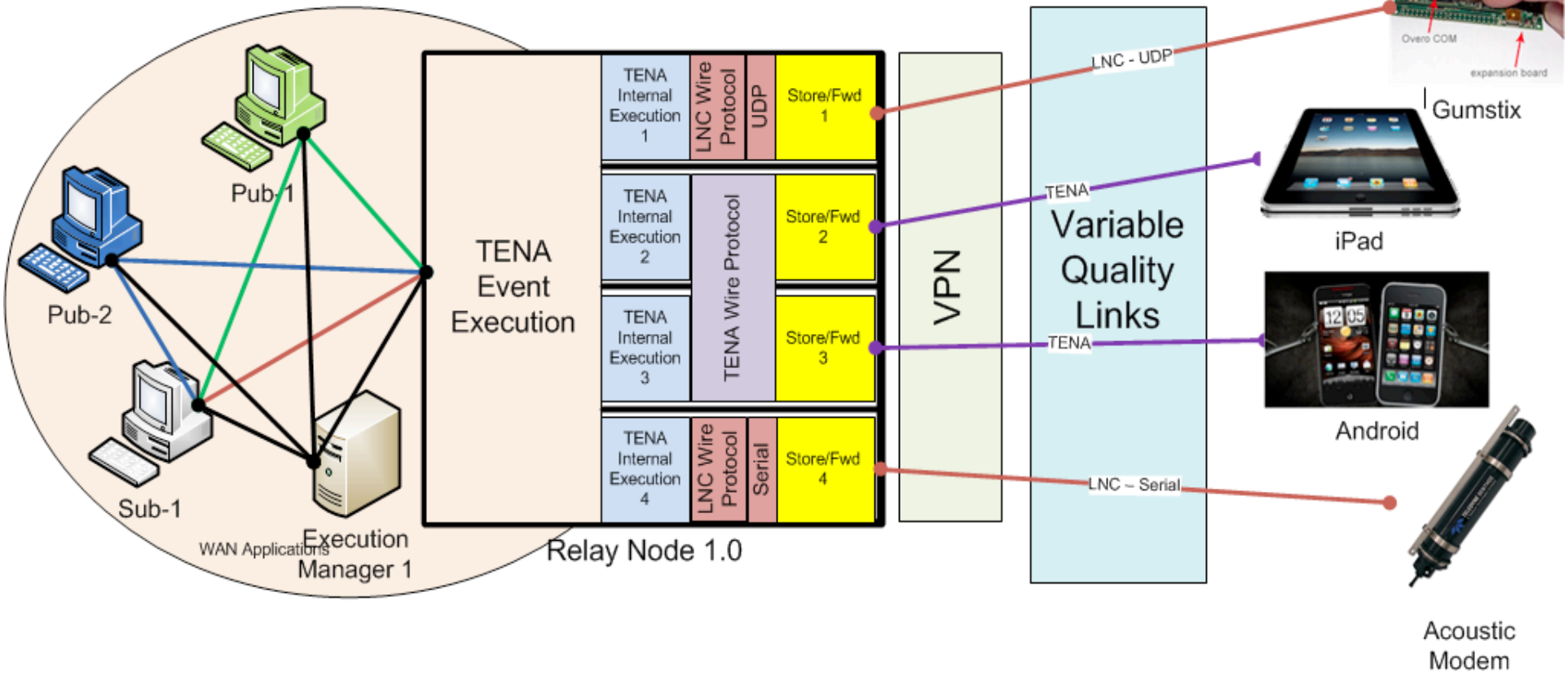
TRCE Use Case OV-1

TENA on a "Smartphone"

- **TENA RelayNode and TENA Video Distribution System (TVDS) with iPads and iPod Touch Devices**
  - Display of Platform positions on static maps stored locally on the handheld devices
  - Selection and real-time viewing of available video streams managed by TVDS on handheld devices (iPhone/iPad/Android)
  - Pan/Tilt control of remote cameras (and trigger devices) via TENA remote methods
- **Highlights the Flexibility of TENA Middleware**
  - Remote control of instrumentation via TENA Remote Methods
  - Use of wireless networks including 3G
  - Middleware implementations on small form factor computers such as Smartphones



RelayNode 1.0



- **Auto-generated application that will support a wide range of object models**
- **Can be deployed at strategic points geographically on the LAN/WAN**
- **Supports each device connection in separate thread**
- **Will eventually support Bluetooth and Zigbee devices**

Joint Mission Environment Test Capability (JMETC)

JMETC Overview

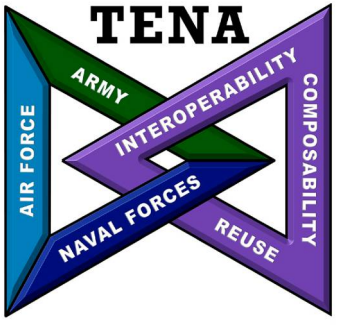
- JMETC provides the infrastructure for testing in a Joint environment
  - Developmental Test, Operational Test, Interoperability Certification, Net-Ready Key Performance Parameters compliance testing, Joint Mission Capability Portfolio assessments, etc.
- Time and cost savings
  - Readily-available, persistent connectivity with standing network security agreements
- Increased capability/connectivity
  - Enables more robust testing earlier in the acquisition process
  - Provides common, certified tools to streamline integration process
  - Establishes test capability aligned with Joint National Training Capability (test and training)
- Being built based on customer requirements

Used whenever you need to link resources together to conduct a distributed test event

What is JMETC?

- A corporate approach for linking distributed facilities
  - Enables customers to efficiently evaluate their warfighting capabilities in a Joint context
  - Provides compatibility between test and training
- A core, reusable, and easily reconfigurable infrastructure
  - Consists of the following products:
    - Persistent connectivity
    - Middleware
    - Standard interface definitions and software algorithms
    - Distributed test support tools
    - Data management solutions
    - Reuse repository

JMETC Network using SDREN



TENA Software, Object Models, Tools, Repository

- Provides customer support team for JMETC products and distributed testing

The JMETC Mission

JMETC provides the ***persistent and robust infrastructure (network, integration software, tools, reuse repository)*** **and** ***technical expertise*** to integrate Live, Virtual, and Constructive systems for test and evaluation in a Joint Systems-of-Systems and Cyber environment

What is Distributed Testing?

A process, preferably persistent and continuous, for linking various geographically separated Live, Virtual, and Constructive sites and systems together in a distributed environment, for use across the acquisition life cycle, to support and conduct the Test and Evaluation (T&E) of a system or systems-of-systems.

A new way of thinking for many in the Test and Evaluation enterprise

Should you consider distributed test for your program?

- Do you have a requirement for Joint Interoperability or a Net Ready KPP? If so, how will you test?
- Are you lacking an adequate numbers of systems “on site” for live testing?
- Do you need more system density or fidelity than what is available “on site”
- Do you need an Operationally Representative environment?
- Would you like to work out basic one-on-one interoperability prior to live testing?
- Need to integrate R&D, DT, and/or OT activities?
- Do you have a tight time line for data collection and analysis?
- Have you made system improvements that are better tested with the existing system of systems baseline before formal DT or OT?

Did you answer ‘Yes’ to any of these?

DoD Acquisition Today

- Systems, Systems of Systems, and Families of Systems are all designed, developed, and assembled disparately
  - Evaluation is holistic under Joint Capabilities Integration Development System (JCIDS)
  - Result: Integration and T&E are exponentially more difficult
  - Consequentially, acquisition programs run over budget
- Weapon Systems Acquisition Reform Act of 2009
  - Creation of Developmental T&E (DT&E) and Systems Engineering (SE) organizations
  - Competitive Prototyping Required

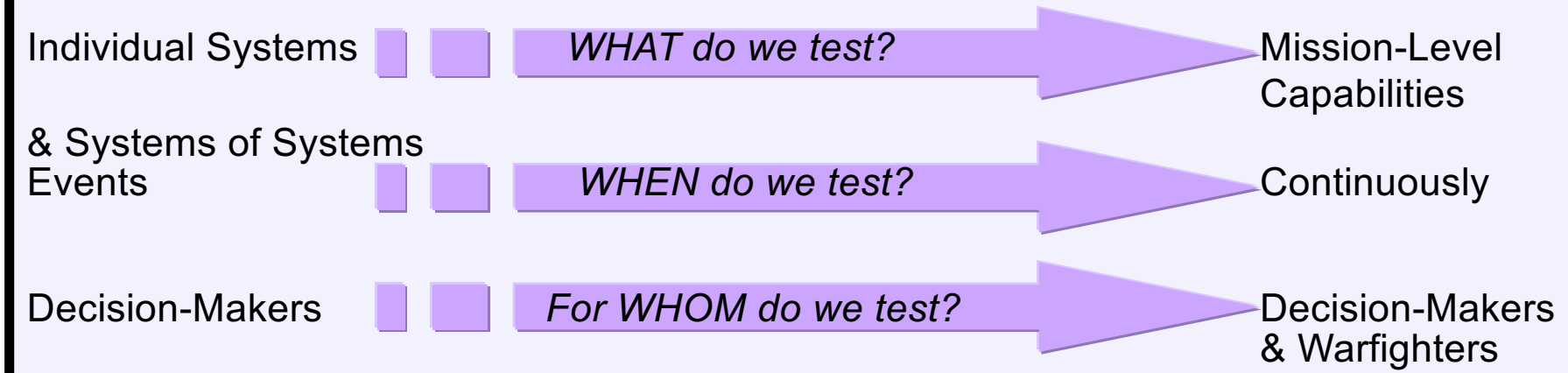
Distributed testing is essential for creating cheaper, faster, and more rigorous test environments early in the acquisition cycle

Test Resource Management Center

Future T&E Process

The DoD T&E process must evolve to be:

- Agile
- Streamlined
- Affordable
- Continuous



Goal: Distributed, Integrated Testing and Training

JMETC Connectivity

Functional Sites: 78

New Sites Planned: 15

Connection Points to Other Networks: 7

- Dedicated, trusted connectivity on SDREN (part of the GIG)
- Encrypted for Secret – System High
- DISA-registered IP address space
- Active monitoring of network performance
- Capable of supporting multiple simultaneous test events

Boeing LabNet Tukwila
Keyport NUWC
Ft. Lewis EPG

Site in Alaska
Ft. Greely: CRTC

Edwards (2): Ridley
412th EWG IFAST
China Lake (3): F/A-18, IBAR, TSPIL
Point Mugu (3): ITEC, EA-6B. EW CyCon
Camp Pendleton: MCTSSA
Corona: NSWC
Palmdale, BAMS
Point Loma:
SSC-PAC 59140
SSC-PAC HAIPE
SSC-PAC JEDI
West Agg Rtr.
Rancho Bernardo, NGC BAMS

Sites in Hawaii
PMRF: Bldg 105
MHPCC

Dugway Proving Ground
Raytheon Tucson
Yuma PG
Kirtland AFB DMOC
Tinker AFB AWACS
Ft. Sill (2): FSED, SMART Lab
WSMR IRCC
Ft. Bliss MCC
Ft Huachuca: (5) JITC, JTDL, CMIS, JTRS, EPG
Ft Hood (2): CTSF, TTEC
Greenville Rivet Joint
Boeing LabNet Berkeley
Crane (2): NSWC RDT&E, NTN Lab
WPAFB: SIMAF
Redstone (10): SMDC
RTC: DTCC, DISTL
SED: Patriot, THAAD, FAAD, GSIL, JLENS, MUSE, C-RAM
AMRDEC
JMETC NOSC
GTRI
Eglin AFB (5): AOC, DTF, GWEF, KHILS, JDAT
CCF
Charleston (2): SSC Data Ctr
MEF-MEU
WNW
Melbourne NGC JSTARS
Orlando NCR
LMCO Global Vision Network

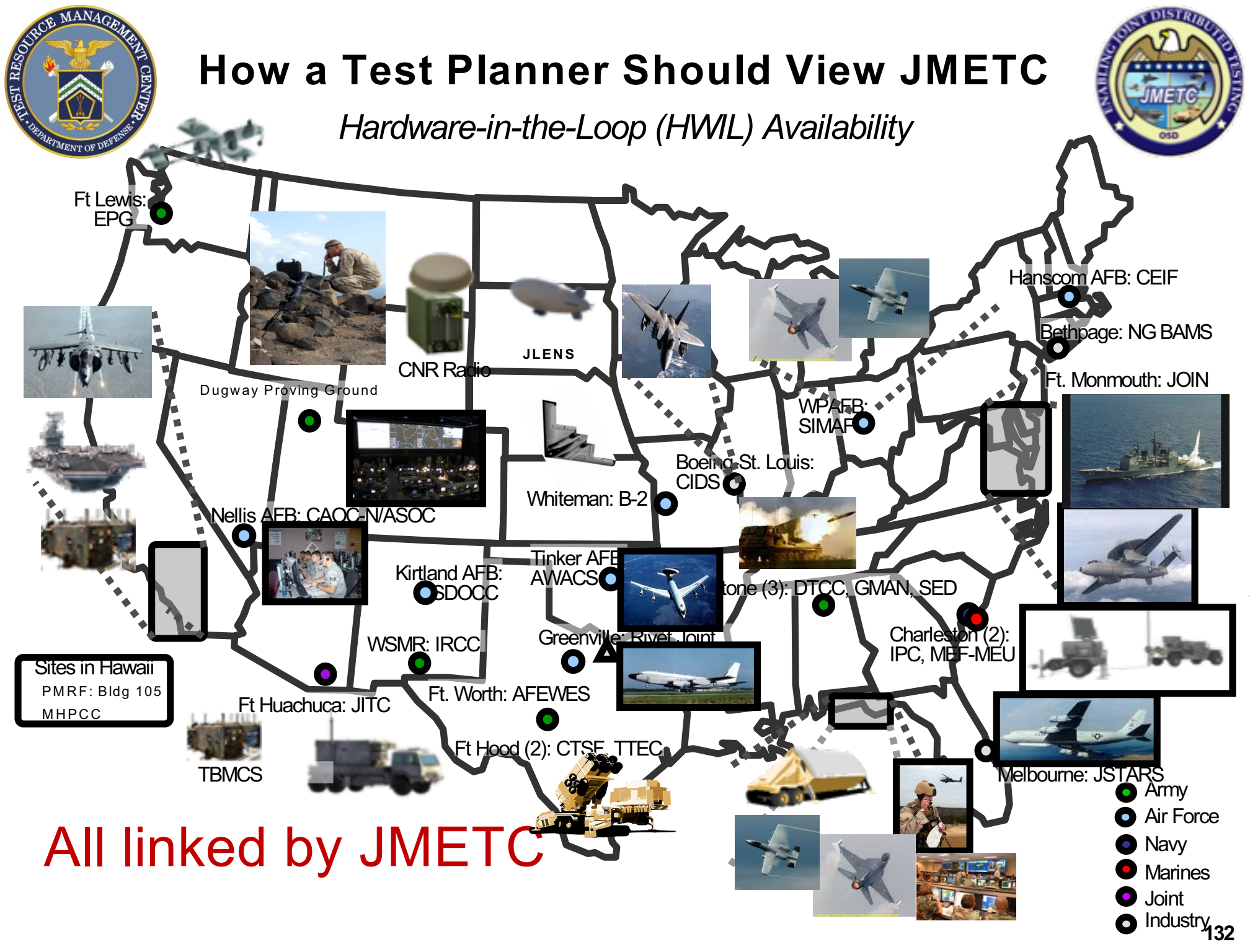
Rome NY AFRL
Hanscom AFB CEIF
Newport NUWC
Bethpage: NGC Triton
Bethpage: NGC BAMS
Moorestown: CSEDS
Aberdeen:
ATC-STE
SRW RIL
Pax River: (9) E2C, E2D, MCL, ACETEF, SAIL, ATR, E-2C SIL, UASIL, MFS
JMETC SYSCON
East Agg Rtr.
Dahlgren:
(2) CEDL,IWSL
(1) Rapid-SIL/C2
JS J8 DDC4 C4AD
Langley (2): C-GIIF, TDLIT
Norfolk COMOPTEVFOR
Dam Neck CDSA
Dam Neck JMETC NOSC
Wallops Island (2): SCSC, SSDS
Newport News NGC VASCIC
McLean MITRE NSEL
Kingstowne SAIC

As of 10 Feb 2014

Army
Air Force
Navy
Marines
Joint
Industry
Academi

How a Test Planner Should View JMETC

Hardware-in-the-Loop (HWIL) Availability



All linked by JMETC

JMETC Event Support Services

- Pre-Test / Test Integration Emphasis:
  - Test Development/Design
    - Convert customer infrastructure requirements into JMETC-provided infrastructure solutions
  - Network Engineering
    - Designs, configures, establishes, and baselines connectivity solutions for test customers
  - IA Engineering
    - Ensures strong security posture for entire JMETC infrastructure
    - Works with JMETC sites directly to mitigate risks associated with IA and security
  - User Support
    - Ensures JMETC sites have the knowledge, skills, abilities, and site-specific examples to address test resource interoperability issues
    - Realizes test workarounds to event-specific interoperability issues
- Test Execution Emphasis:
  - JMETC SYSCON
    - Verifies infrastructure readiness and proactively troubleshoots problems as they are discovered
    - Partnership with NAVAIR AIC 5.4.1
  - Event Support
    - Provides direct support to customer test activities on an as-needed basis
- Post Test Emphasis:
  - Capture Lessons Learned and Infrastructure Gaps/Limitations

Major FY13 Events

Customer	Event	Execution Dates	Onsite Support
Navy	Accelerated Mid-Term Interoperability Improvement Program (AMIIP)	Oct 2012 - Sep 2013	**Yes**
Joint	JITC Joint Interoperability Tests (JIT)	Oct 2012 - Sep 2013	**Yes**
Air Force	Air Force Systems Interoperability Test (AFSIT)	Oct 2012 - Sep 2013	**-**
Navy	MQ-4C TRITON	Oct 2012 - Sep 2013	**Yes**
Joint	Joint Track Manager Concept - Demonstration (JTMC-D)	Oct 2012 - Sep 2013	**Yes**
Joint	JIAMDO Correlation/De-correlation Interoperability Test (C/DIT) Coalition and U.S. only	Oct 2012 - Sep 2013	**Multiple**
Joint	JIAMDO Joint Tactical Air Picture (JTAP)	Oct 2012 - Sep 2013	**Multiple**
Air Force	AGILE Fire Phase VII	Jan 2013 - Mar 2013	**Multiple**
Joint	InterTEC Cyber Event (ICE) FY13	Oct 2012 – Feb 2013	**Multiple**
Navy	Virtual Rapid Prototyping Laboratory	Jan 2013 – Feb 2013	**Yes**
Joint	Red Flag	Jan 2013 – Mar 2013	**Yes**
Navy	Joint Distributed IRCM Ground test System(JDIGS)	Oct 2012 - Sep 2013	**-**
Air Force	AIM9x	Feb 2013	**Yes**
Marine Corp	G/ATOR	Feb 2013 – Apr 2013	**Yes**
Air Force	AGILE Fire Phase VIII	Jun 2013 - Sep 2013	**Multiple**

Major FY14 Events

Customer	Event	Execution Dates	Onsite Support
Navy	Joint Distributed IRCM Ground test System(JDIGS)	Oct 2013	-
Navy	Accelerated Mid-Term Interoperability Improvement Program (AMIIP)	Ongoing	**Yes**
Joint	JITC Joint Interoperability Tests (JIT)	Ongoing	**Yes**
Air Force	Air Force Systems Interoperability Test (AFSIT)	Ongoing	-
Navy	MQ-4C TRITON	Ongoing	-
Navy	Virtual Rapid Prototyping Laboratory	Jan 2013 – Feb 2013	**Yes**
Air Force	AGILE Fire Phase VIII	Oct 2013 - Feb 2014	**Multiple**
Joint	Snakehead	Oct 2013 - Dec 2013	**Yes**
Navy	Advanced Anti-Radiation Guided Missile (AARGM)	Ongoing	**Yes**
Navy	Multi Site Training Capability Test (MSTCT)	Ongoing	-
DOT&E	Enterprise Cyber Range Environment (ECRE)	Dec 2013 - Jun 2014	**Multiple**
Joint	JIAMDO Correlation/De-correlation Interoperability Test (C/DIT) Coalition	Dec 2013 - Jan 2014	**Multiple**
Army	Apache Block 3 JIT Risk Reduction	Mar 2014 - Apr 2014	**Yes**
Navy	Integrated Warfare Center (IWC) LVC Demo	Apr 2014 - May 2014	**Multiple**
Air Force	F-35 Information Exchange Requirements (IERs) Test	Jun 2014	**TBD**

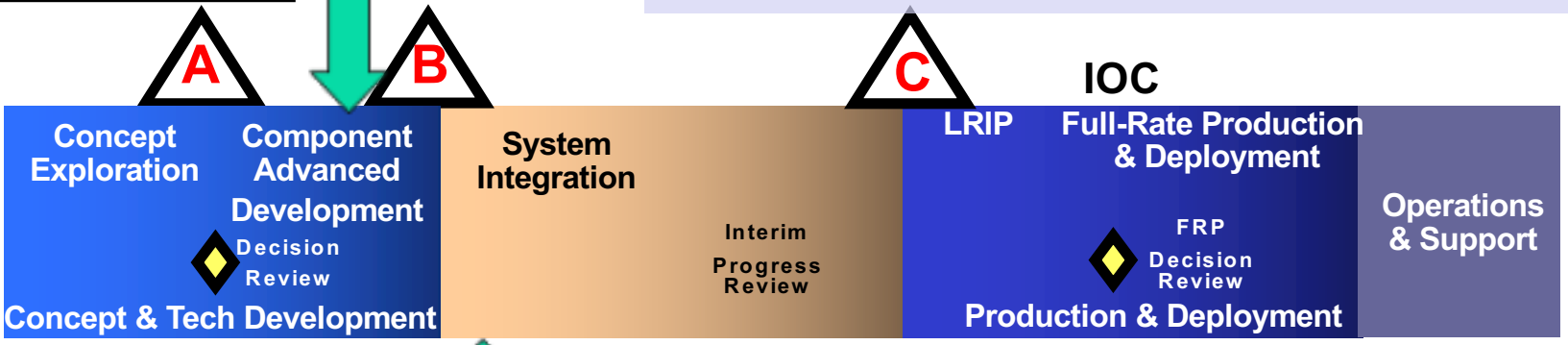
Major FY15 JSN Events

Customer	Event	Execution Dates	Onsite Support
MDA/Navy	Ballistic Missile Defense (BMD) Critical Experiment	Nov 19-21, 2014	No
MDA/DARPA	DARPA Air Dominance Initiative (ADI)	Dec 1-5, 2014	Yes
Joint	P-8A/High Value Unit (HVU) Escort, Anti-Submarine Warfare (ASW) Simulation Experiment (SIMEX) 15-2	Dec 8-12, 2014	Yes
NAVSEA	Interoperability Development & Certification Test (IDCT)	Dec 8-12, 2014	Yes
USSTRATCOM	Distributed Test Demonstration	Dec 15-19, 2014	Yes
Joint	F-35 Record/Playback	Jan 12-16, 2015	Yes
Joint	JITC Joint Interoperability Tests (JITS)	Jan 20-30, 2015	Yes
Joint	Joint Unmanned Air System (JUAS)	Jan 26-30, 2015	Yes
Air Force	Air Force Systems Interoperability Test (AFSIT)	Feb 2-20, 2015	--
Navy	Integrated Flight Demonstration (IFD) Live Fly	Feb 4-5, 2015	Yes
Navy	Aegis BDM Baseline	Feb 24-Mar 13, 2015	Yes
Joint	F-35 Record/Playback	Feb 24-27, 2015	Yes
Joint	JITV Joint Interoperability Tests	Mar 17-31, 2015	Yes
Navy	Aegis Integrated Air Missile Defense Baseline Test	Mar 23-27, 2015	Yes
MDA/Navy	Distributed Weighted Engagement Scheme (DWES)	April 20-24, 2015	Yes
Joint	Distributed Integration & Interoperability Assessment Capability (DIIAC) BMD FST	June 8-12, 2015	Yes
Joint	JITC Joint Interoperability Test	June 29- July 7, 2015	Yes
Joint	F-35 Record/Playback	Aug 20-28, 2015	Yes
Joint	Simulation Exercise 15-5 (SIMEX)	Aug 24-28	Yes
Joint	Joint Unmanned Air System (JUAS)	Sept 15-17, 2015	Yes
Joint	JIAMDO Correlation/De-correlation Interoperability Test (C/DIT)	Sept 14-18, 2015	Yes

JMETC Allows You to "Test Early and Test Often" Across the Acquisition Life Cycle

Outline Distributed Testing and JMETC requirements in TEMP

Rapid Acquisition, Developmental Test, Operational Test, Interoperability Certification, Net-Ready Key Performance Parameters testing, Joint Mission Capability Portfolio testing



Pre-Systems Acquisition

Systems Acquisition (Engineering & manufacturing development, demonstration, LRIP & production)

Sustainment

Enables early verification that systems work stand alone and in a Joint Environment

Helps find problems early in acquisition – when they are less costly to fix

Support to Acquisition Programs with the expertise to integrate distributed test facilities

JMETC enables continuous testing across the acquisition life cycle

JMETC reduces acquisition time and cost

By Providing

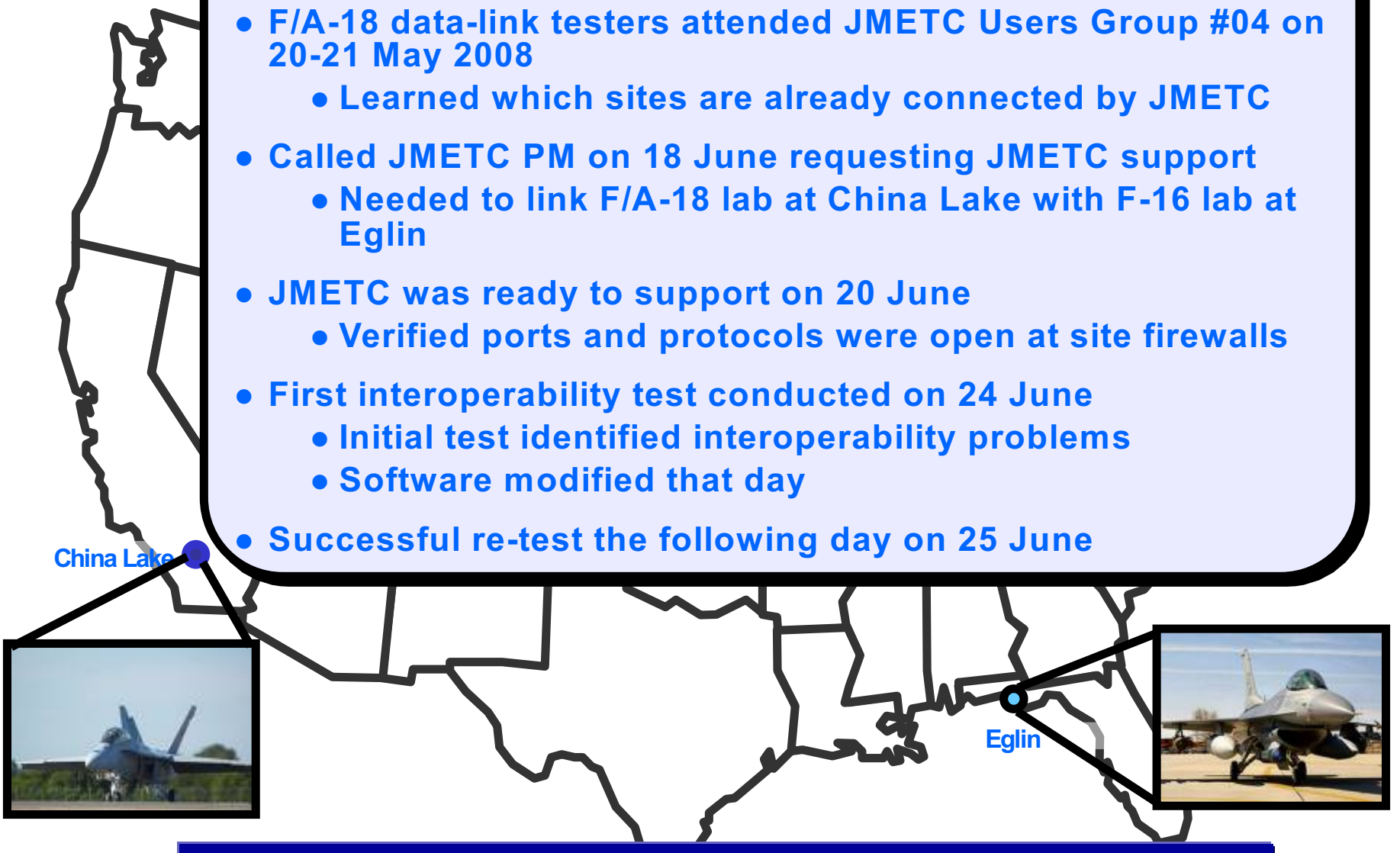
- Readily-available, persistent connectivity to government and industry
- Standing network security agreements
- Common interoperability software for linking sites
- Certified test tools for distributed testing

An Example Distributed Test

Example: F/A-18 Interoperability Check

Sequence

- F/A-18 data-link testers attended JMETC Users Group #04 on 20-21 May 2008
  - Learned which sites are already connected by JMETC
- Called JMETC PM on 18 June requesting JMETC support
  - Needed to link F/A-18 lab at China Lake with F-16 lab at Eglin
- JMETC was ready to support on 20 June
  - Verified ports and protocols were open at site firewalls
- First interoperability test conducted on 24 June
  - Initial test identified interoperability problems
  - Software modified that day
- Successful re-test the following day on 25 June



One week from initial coordination to test complete!

Pre-Milestone A– Concept Development

Joint Surface Warfare JCTD

Description:

Point Mugu Test Team demonstrated Net Enabled Weapon Link-16 capability using F/A-18E/F as launch platform, JSOW C-1 as weapon, and JSTARS as 3rd party target source

Distributed Tests:

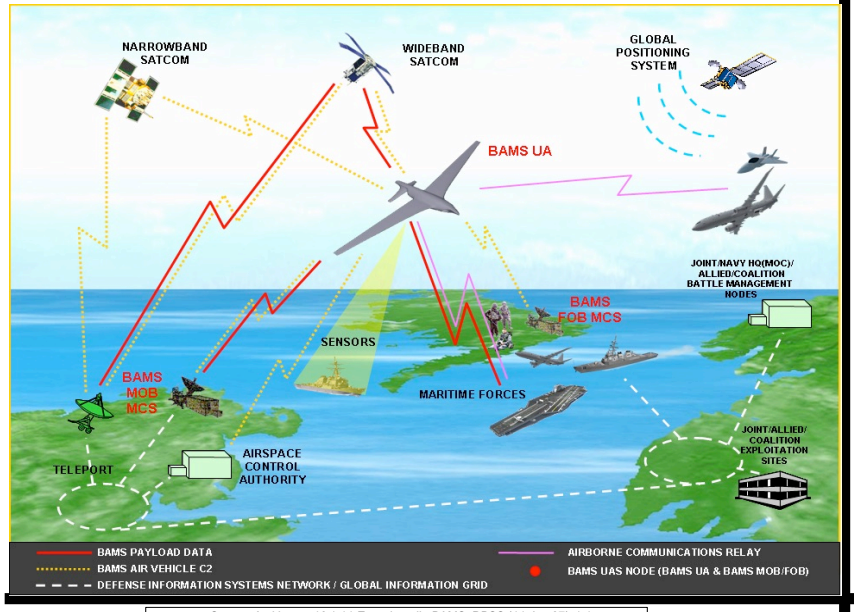
- 09-11 Mar 2010
- 04-05 May 2010
- 17-19 Jun 2010
- 31 Aug – 01 Sept 2010

IMPACT-- Efficiency, Lower Technical Risk, and Cost Savings

- Program scheduled and executed short multiple tests for incremental software update evaluation
- Resources expended on test & analysis and not network setup and monitoring

Post-Milestone B - Developmental Test

Broad Area Maritime Surveillance Unmanned Aircraft System (BAMS UAS)



System Architect v 10.1.11 Encyclopedia BAMS_PBSS (11 Jan 07)v1.1

Program Description:

BAMS UAS is an integrated Systems of System that will provide multi-sensor persistent maritime ISR to the Maritime Patrol and Reconnaissance Force

Program Status/Events:

BAMS planned sites are: Bethpage – NGC MSSIL (existing), Rancho Bernardo, Dam Neck C2/SA/TCC/MOC (existing), Palmdale NGC SIL, NAS Patuxent River (existing)

Current BAMS schedule: June 2012 (6-12 months) NGC lead. June 2013 – IOC Pax Lead

Program Support Plan signed by BAMS and JMETC

Issues:

Considering peering with BAMS Classified Network (BCN) but may be separate agreement with NGC

Event Support Plan for flight test needs to be completed, ESP format changes under review by ENG/DOPS

Both BAMS and NGC are still discovering potential T&E requirements including various networks that BAMS interfaces with for flight

Pre-Milestone C – Operational T&E
Joint Interoperability Certification

Description:

- JITC conducts interoperability assessments, standards conformance and interoperability certification testing of Joint Tactical Data Links in HWIL and operationally realistic environments to validate the implementation of approved standards in a Joint environment.
- JITC uses JMETC connectivity and tools for Joint Tactical Data Link Testing

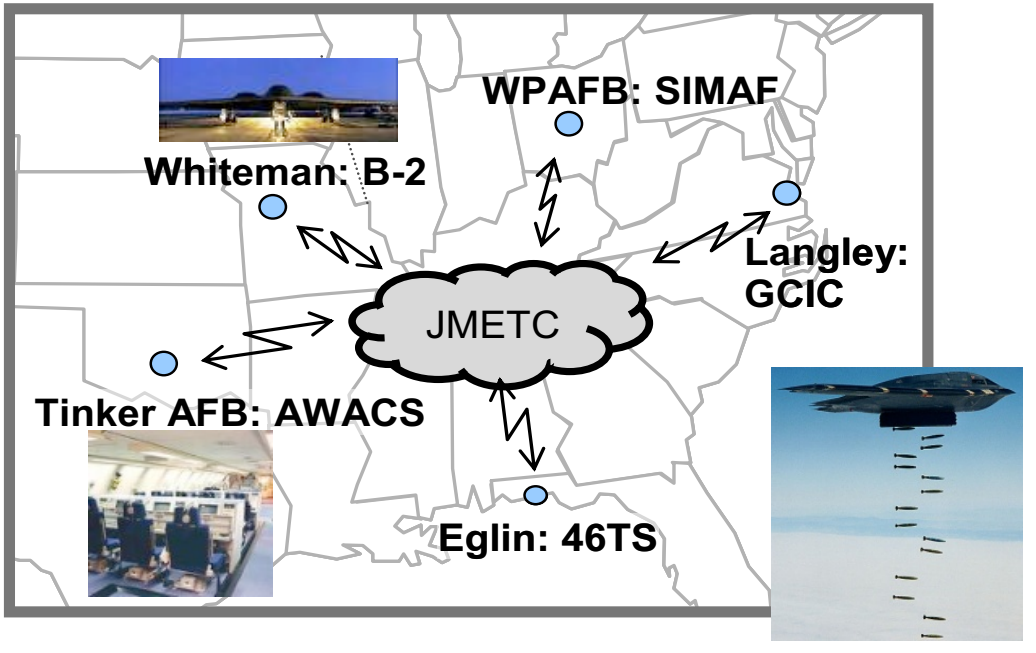
IMPACT--Test Commonality

- JITC Interoperability Certification is required for Net Ready KPP for all ACAT Programs
- First Joint Interoperability Tests on JMETC infrastructure completed August/November 2010

Post-Milestone C – Developmental Test
B-2 Spirit ICE Data Link Test

Description:

- JEFX assessment of B-2 Link-16 interoperability challenges with AWACS
- Connected live B-2 on ramp at Whiteman AFB, MO, an AWACS HITL at Tinker AFB, OK, within a distributed C2 environment
- Time sensitive targeting scenarios with combat ready crews



IMPACT-- Cost Savings and Better Product

- Early testing led to early identification and correction of Link 16 interoperability issues
- No range or flying costs

Post-Milestone C – Operations and Support
JIAMDO JSI & C/DIT 10

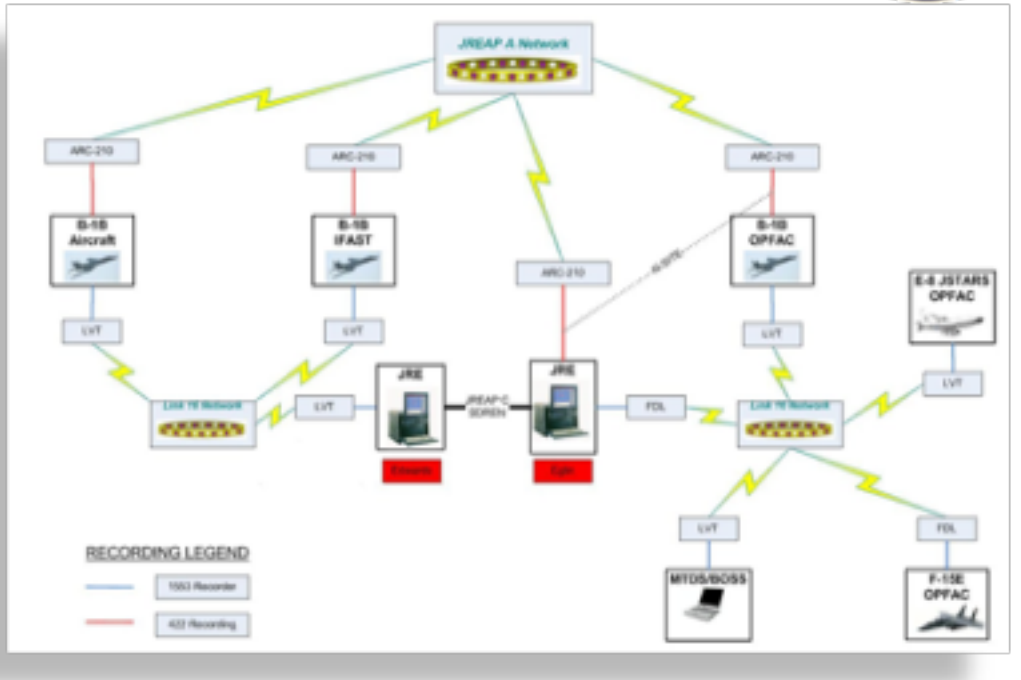
- Joint Integrated Air & Missile Defense Organization (JIAMDO) sponsored programs addressing full scope of System Track Management
  - Joint Sensor Integration (JSI) Goal: Integrate national, theater, and tactical sensors and processors to better utilize existing sensor inputs
  - Correlation / DeCorrelation Interoperability Test (CDIT) Goal: All-Service & Coalition Integration of Track Management to fully realize existing capabilities
- JMETC Infrastructure Serves as Joint Development Testbed
  - Identify Joint and Multi-mission architectural issues as they apply within: Net Centric Operations, Battle Management, Command and Control (C2), and Intelligence, Surveillance, and Reconnaissance (ISR)
  - Integration behavior anomalies are discovered, modifications made and retested in real time
  - Modified Infrastructure as needed to support testing
    - Changed scenario files, Test Roles, IFF loads, Participants, etc. without need for re-integration

Rapid Testing / Rapid Turnaround / Rapid Progress!

JMETC Customer Testing Success

B-1 Fully Integrated Data-Link (FIDL) Testing

- FIDL PM requested testing of fixes made on issues identified in previous distributed test
- JMETC connected 46 TS Datalinks Test Facility at Eglin AFB to Ridley Mission Control Center
- B-1 flew in the Edwards airspace and received Link 16 data from distributed sites
- Allowed for weather and maintenance delays without incurring additional test costs
- Follow-on from 2009 testing



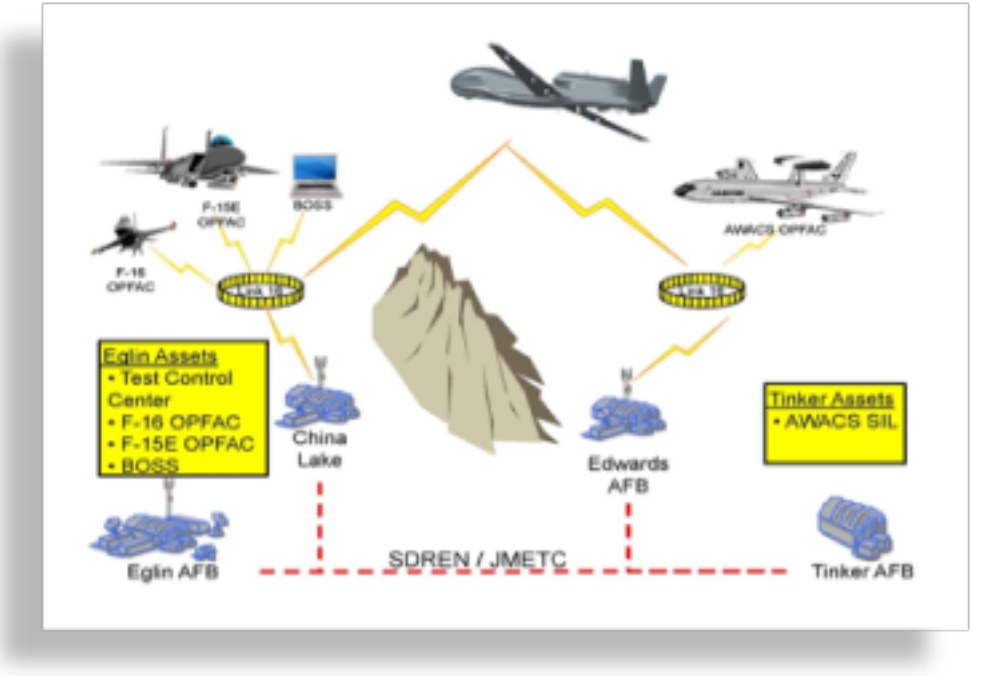
IMPACT

- **Significant cost savings**
- **Tested Link 16 data exchange with several platforms using a single live fly asset**
- **Supported over 30 hours of live fly test time**
- **2009 distributed testing showed system not ready**

JMETC Customer Testing Success

Battlefield Airborne Communication Node (BACN) Joint Urgent Operational Need

- Integration of BACN payload onto multiple platforms for solution to urgent in-theater need :
  - Combat requirement for beyond line-of-sight comm
  - Relay, bridge, and range extension for ground forces and supporting aircraft
- Distributed Testing in Fall 2010 included Live-fly , DT, and Operational Utility Evaluation



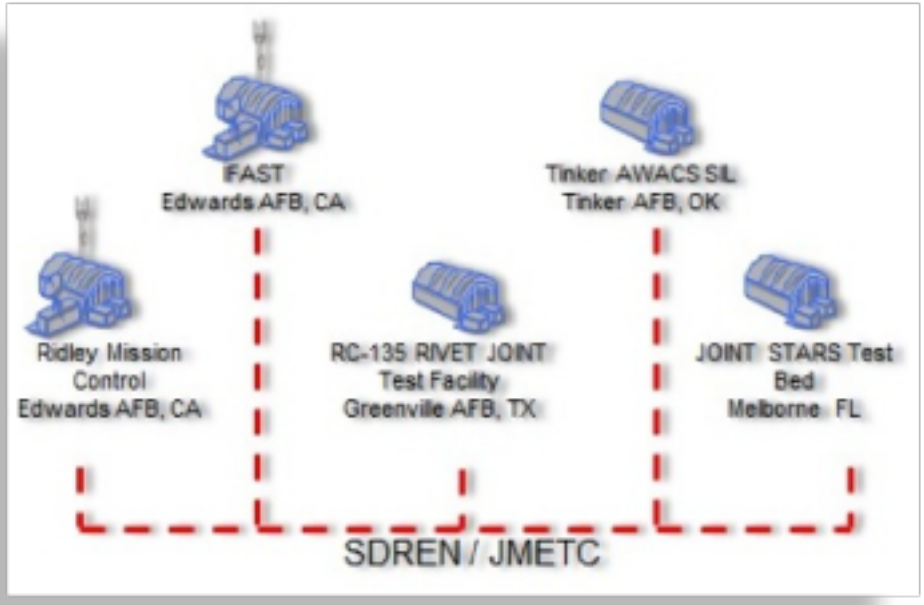
IMPACT

- **Efficient integration of DT and OT**
- **Testing completed despite many of the required assets not being available on-site**
- **Distributed Testing saved "$1.2M" (OTA)**
- **Urgent capability fielded-quickly!**

JMETC Customer Testing Success

B-52 Combat Network Communications Technology (CONECT) Ground Interoperability Test

- Regression testing of software upgrades made based on previous tests
- Demonstrated JREAP interoperability TDL network messages between several weapon systems
- Connected HWIL facilities at Edwards AFB, Tinker AFB, and Melbourne, FL



IMPACT

- **Increased B-52 operational effectiveness**
- **Provided improved mission flexibility, increased situational awareness, new network-centric capabilities**
- **JMETC infrastructure supported rapid test-fix-test cycle of the CONECT messaging capabilities**

JMETC Customer Testing Success

Correlation / Decorrelation Interoperability Test (C/DIT) Coalition Testing

- A Joint Integrated Air and Missile Defense Organization (JIAMDO/J8) Joint Distributed Engineering Plant (JDEP) sponsored event
- Assess correlation/de-correlation interoperability of STANAG 5516 Ed 4 and Mil-Std 6016D for the E-2C and E-3D.
- Assess STANAG 5602 Ed 3 interoperability between the US & UK platforms using their SIMPLE protocol communication devices

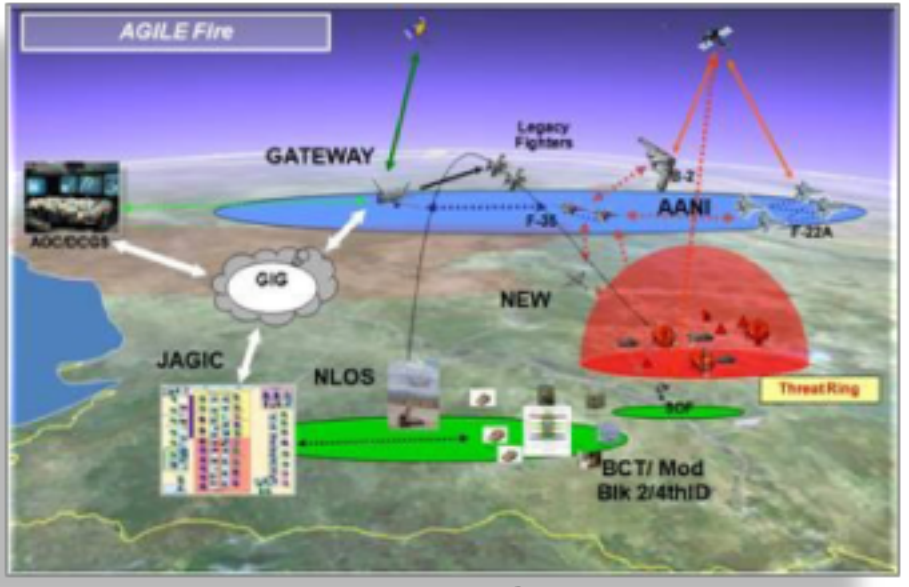
IMPACT

- **Improved Coalition Interoperability**
- **US: HE2K (E2C), ESTEL, Pax River, MD**
- **UK: E3D (baseline UK04v10), RAF Waddington**
- **Demonstrated JMETC ability to connect to Coalition partners.**

SIMAF Sponsored Air-to-Ground Integrated Layer Exploration (AGILE)

A Distributed Test Venue

- Sponsored by the Simulation and Analysis Facility (SIMAF), USAF Air Systems Command (WPAFB, OH)
- Distributed venue for selected initiatives to explore Joint airspace integration procedures and data exchange requirements within and between Air and Ground domains to execute Joint Fires
- Provides bi-annual robust integrated LVC environment for capturing data based on project requirements
- JMETC provides infrastructure and technical support for all AGILE events
  - Only JMETC sites are used
  - 12-15 sites each cycle
- AGILE VII: 25-29 March, 2013



IMPACT

- T&E Efficiencies
- Since FY 12 & 13, programs Included: Network Enabled Weapon (SDB II); Common Aviation Command and Control System (CAC2S); Counter Rocket, Artillery, and Mortar (CRAM); Friendly Force Tracker (FFT); Joint Air-to-Ground Integration Cell (JAGIC)
- AGILE VI (Sept 2012) included 13 Initiatives and four operationally realistic mission threads

JMETC Customer Testing Success

AIM-9X Air to Air Missile Captive Carry Tests
(On-going)

- Capability to remotely observe live seeker head video and real-time position of the test aircraft presented in a 'gods-eye' view of the China Lake Range
- Remotely monitor live aircraft communications between the test aircraft and China Lake Range Control
- JMETC connects Naval Air Warfare Center Weapons Division China Lake, CA Open Air Range to the COMOPTEVFOR Norfolk, VA via the Integrated Battlespace Arena (IBAR)

IMPACT

- **Increased capability for Operational Testers to observe more DT & OT test flights (20 captive carry tests and 10 live fire tests)**
- **Reduced COMOPTEVFOR's OTA's test observation time from 3 days (including travel) to actual range test time**
- **Utilized existing JMETC infrastructure, IA and engineering expertise in coordination with Navy MRTFB facility to deliver capability with no additional cost to Operational Testers**

Example JMETC Customer: Joint Strike Fighter Record and Playback

JPO Estimated Cost Savings: $10.8M

Overview

Issue:

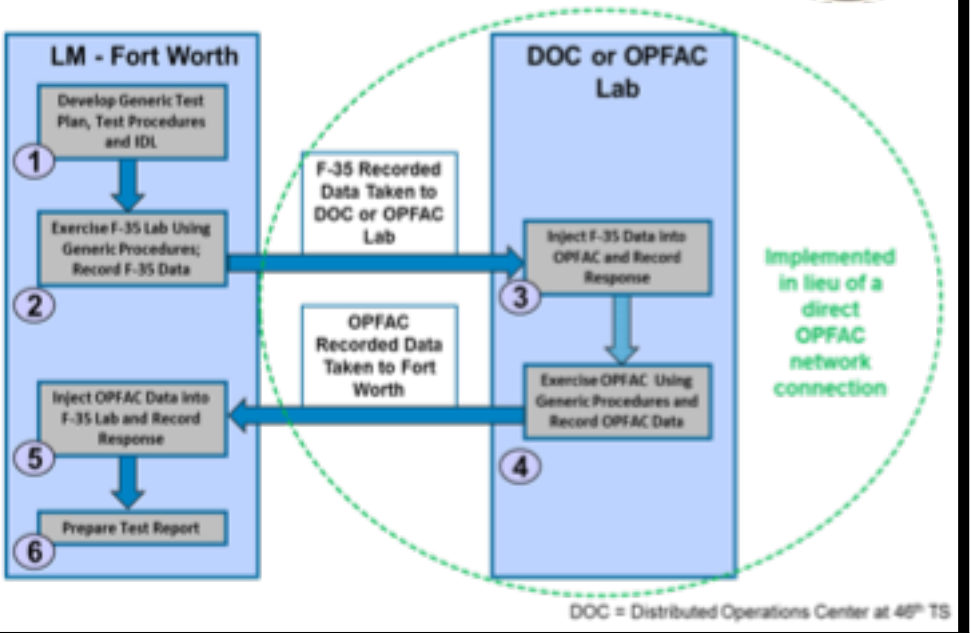
- Unable to connect F-35 HW/SW-in-the-loop missions systems labs to various OPFAC labs due to concerns that real-time interface could not be implemented consistent with F-35 security requirements

Goal:

- Establish repeatable (portable) processes to evaluate F-35 Data Link Information Exchange Requirements (IERs) not verifiable through laboratory testing

Systems:

- FA-18, Aegis, LHD, F-15, F-16 , JSTARS, E2-C, EP-3, EA-6B, and AWACS



Solution

Solution:

- Adopt Record/Playback Approach
- Connect F-35 HW/SW-in-the-loop Mission systems labs to various OPFAC Labs via SDREN
- Use F-15 OPFAC instance as F-35 surrogate to expand interactions with C2s and increase number of messages that can be tested
- Add dedicated CATB vs. OPFAC flight test at end of SDD to verify high value/dynamic IERs

Benefits:

- Reduces execution costs and total event time span
- Leverages test planning/execution expertise at 46th TS
- Potential to use similar approach in UK

Stakeholders / Phases

Lead Organization: F-35 JPO Interoperability Verification, Test and Accreditation (IVT&A) Team

Sites:

- Air Force: Eglin, Greenville Rivet Joint, Tinker
- Navy: China Lake, Dahlgren, Dam Neck, Pax River, Pt. Mugu
- Coalition: United Kingdom (future)

Test Phases:

- Phase 1 - Surveillance Tracks/Ref. Pts. Message Verification
- Phase 2 - Dynamic Execution – S-35 with AWACS C2
- Phase 3 - Dynamic Execution – S-35 with JSTARS C2
- Phase 4 - S-35/JSTARS Imagery and Free Text Exchange
- Phase 5 - Dynamic Execution – F-16C
- Phase 6 - F-35 Playback

JMETC Benefits

- **Provides Department-wide capability for:**
  - Evaluation of a weapon system in a joint context
  - DT, OT, Interoperability Certification, Net-Ready KPP compliance testing, Joint Mission Capability Portfolio testing, etc.
- **Provides test capability aligned with JNTC**
  - Both use TENA architecture
  - Both use Network Aggregator
- **Reduces time and cost by providing**
  - Readily available, persistent connectivity with standing network security agreements
  - Common integration software for linking sites
  - Distributed test planning support tools
- **Provides distributed test expertise**

JMETC
Distributed Test Architecture

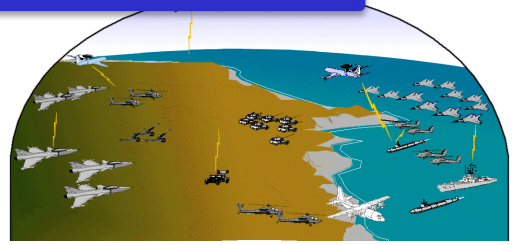
JMETC depends on TENA to support distributed testing

Joint Operational Scenarios

Systems Under Test

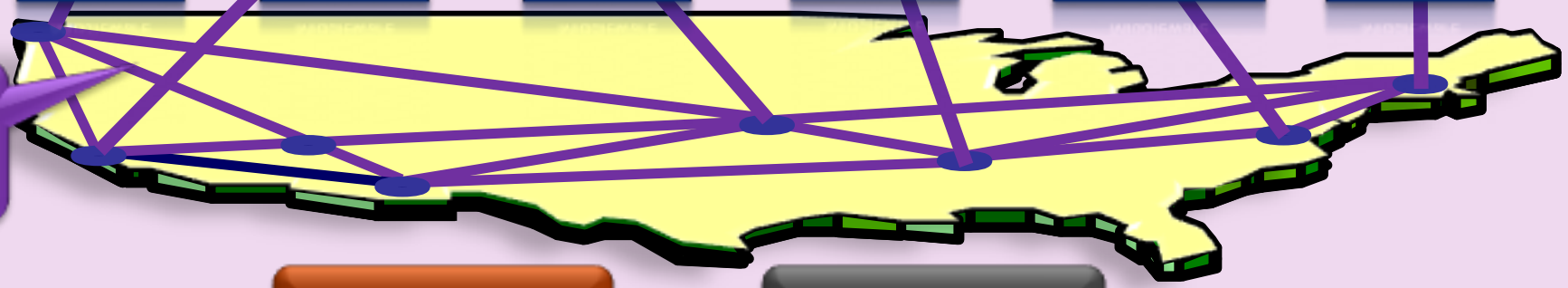






Integrated Test Resources

Virtual Prototype	Hardware in the Loop	Installed Systems Test Facility	Range	Environment Generator	Threat Systems
TENA Standard Interface Definitions	TENA Standard Interface Definitions	TENA Standard Interface Definitions	TENA Standard Interface Definitions	TENA Standard Interface Definitions	TENA Standard Interface Definitions
TENA Common Middleware	TENA Common Middleware	TENA Common Middleware	TENA Common Middleware	TENA Common Middleware	TENA Common Middleware



JMETC Infrastructure on SDREN

Reuse Repository

Distributed Test Support Tools

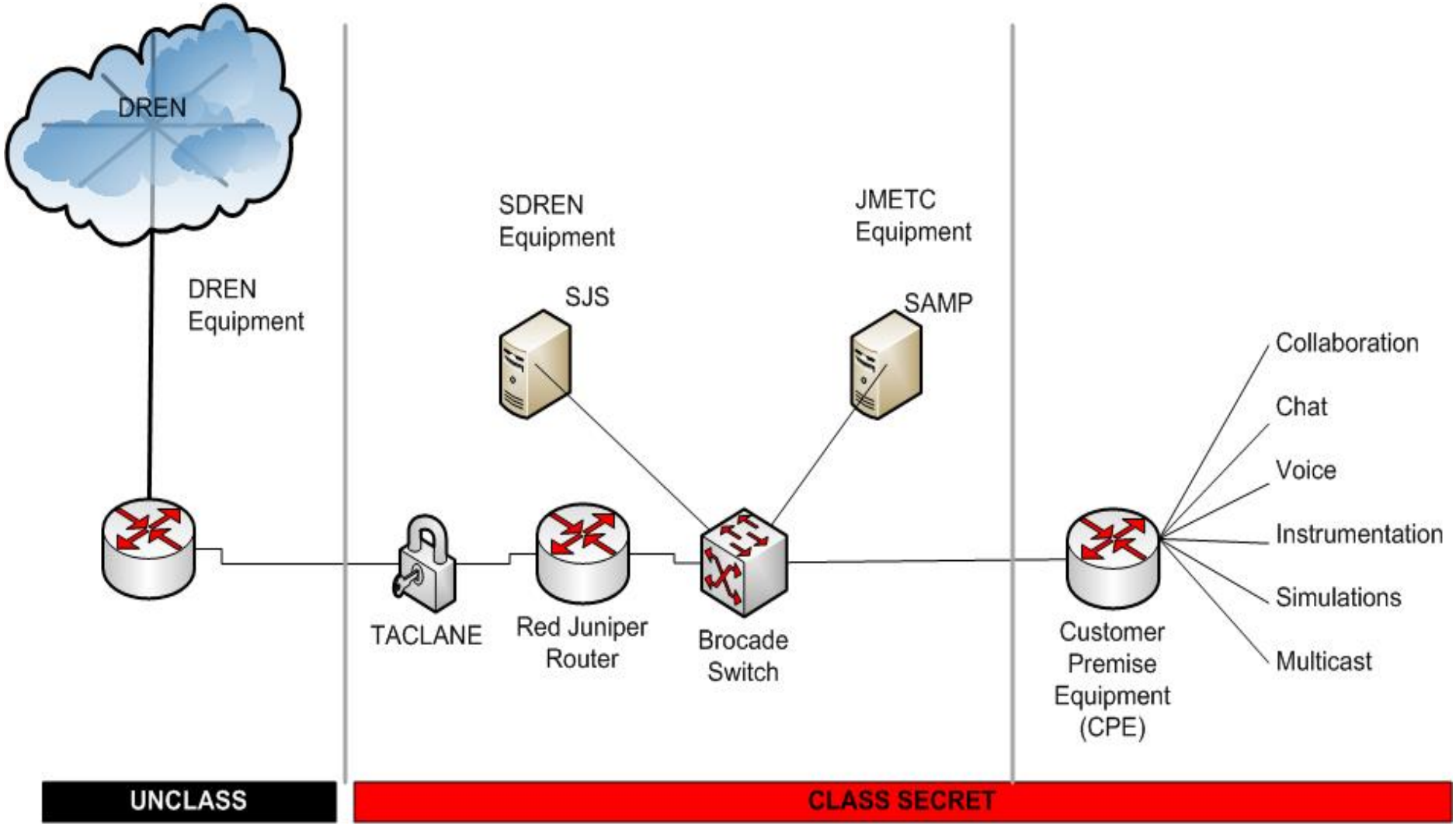
* TENA: Test and Training Enabling Architecture

JMETC Network: Reusable Persistent Connectivity

- Reuse enables the customer to avoid:
  - Acquiring network equipment
  - Processing the security agreements
    - Obtaining Authority to Connect (ATC)
    - Obtaining Authority to Operate (ATO)
  - Generating agreements to connect with test partners
  - Testing the equipment installation
  - Testing the network configuration
- Reuse enables the customer to:
  - Test capabilities early and often
  - Execute unscheduled / unplanned testing whenever needed
  - Focus on the test rather than the network

By leveraging JMETC sites, customer time and dollars are not spent on infrastructure

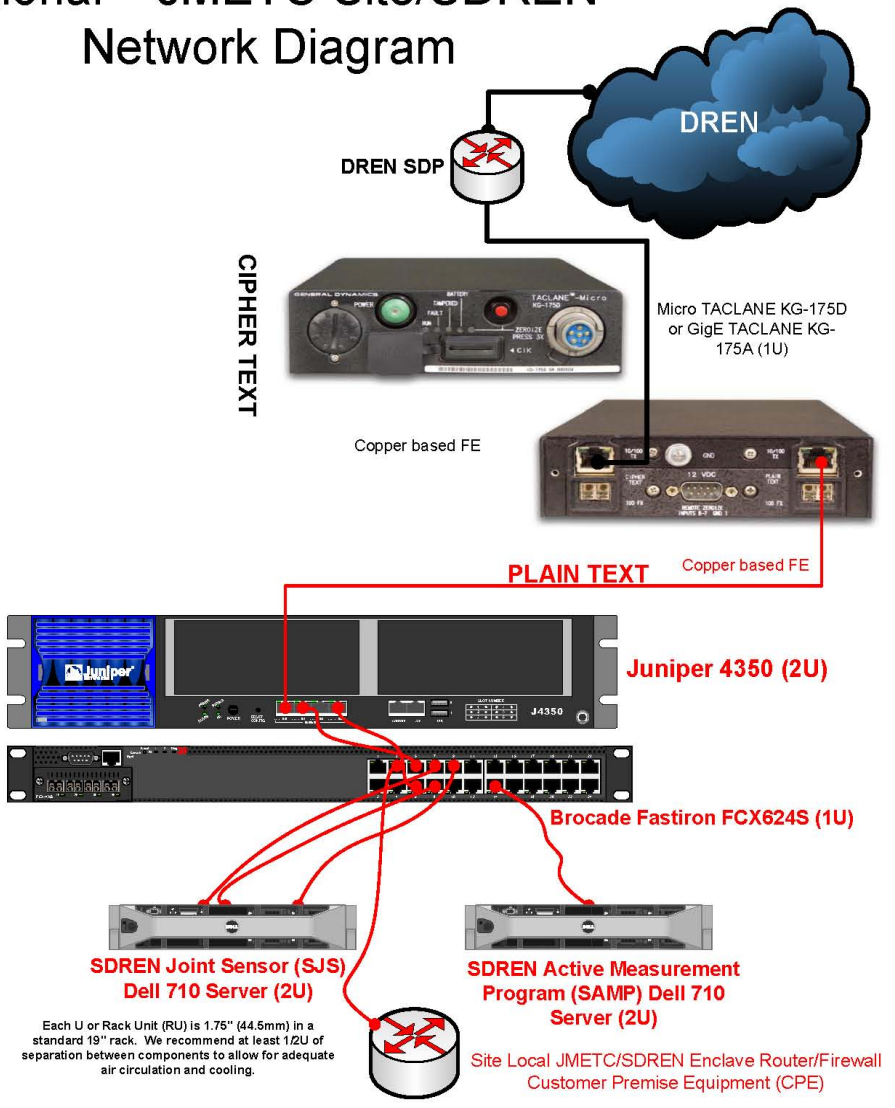
JMETC
Typical Site Configuration



Notional – JMETC Site/SDREN Network Diagram

JUNIPER J4350 ROUTER	
From:	To:
J4350 Port GE-0/0/0	Taclane PT interface
J4350 Port GE-0/0/1	Brocade Port 1/1/5
J4350 Port GE-0/0/3	Brocade Port 1/1/6

Brocade Fastiron FCX624S CONNECTIONS	
From:	To:
Brocade Port 1/1/5	J4350 Port GE-0/0/1
Brocade Port 1/1/6	J4350 Port GE-0/0/3 (VLAN401)
Brocade Port 1/1/7	SDREN Joint Sensor MGMT (Dell Port 1)
Brocade Port 1/1/8	SDREN Joint Sensor (SJS) Collector (Dell Port 2)
Brocade Port 1/1/9	SJS Dell Remote Access Controller (DRAC) Port
Brocade Port 1/1/10	SJS Spare
Brocade Port 1/1/11	SJS Spare
Brocade Port 1/1/12	SDREN (VLAN 100) – Not Used
Brocade Port 1/1/3	JMETC CPE (VLAN 300)
Brocade Port 1/1/14	SDREN Active Measurement Program (VLAN 300)
Brocade Port 1/1/15	JMETC Test Port (VLAN 300)
Brocade Port 1/1/16	SDREN Test Port (VLAN 100)

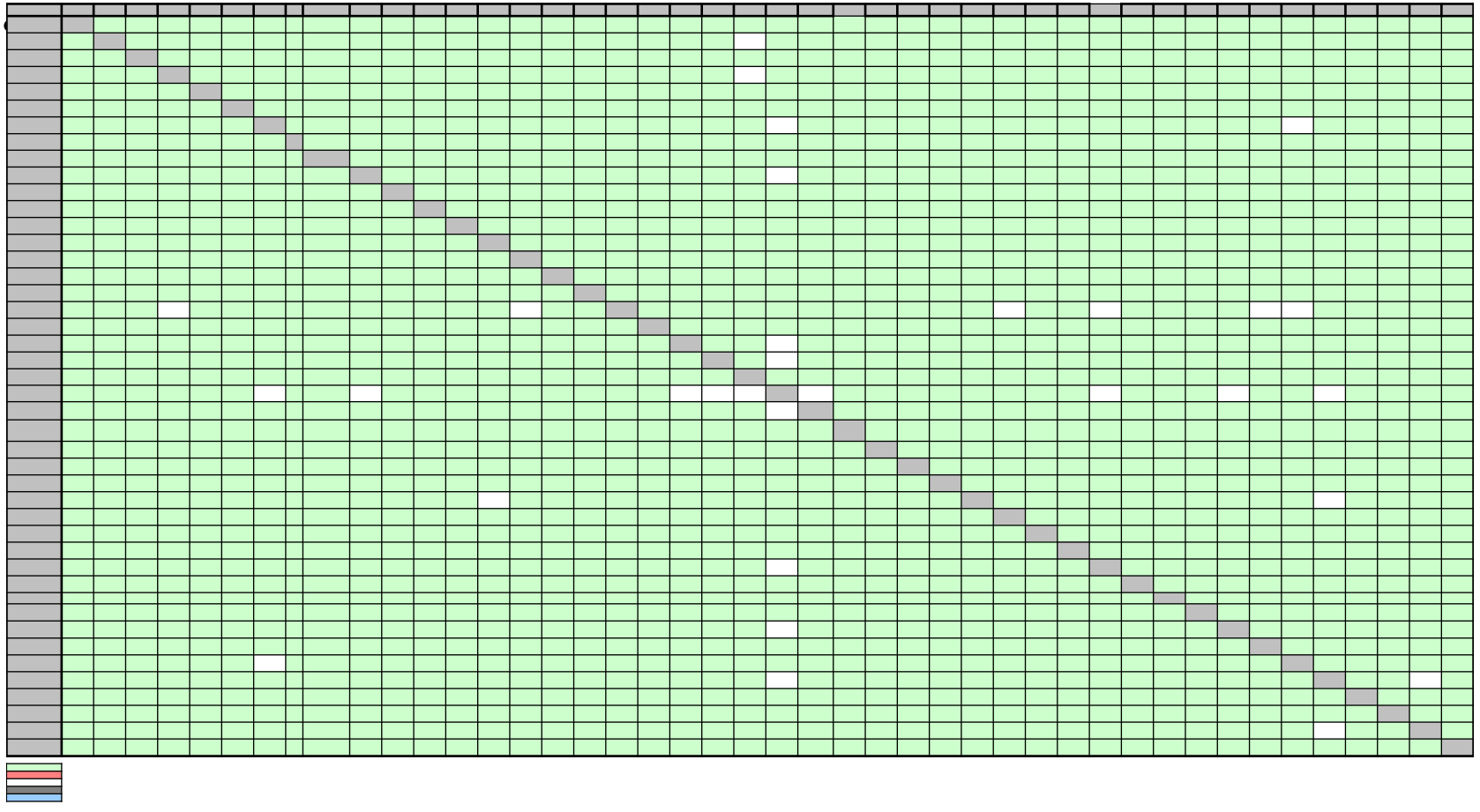


SDREN Active Measurement Program (SAMP) Overview

- Every JMETC Network equipment stack includes a SAMP
- The SAMP is used to collect SDREN Network Performance statistics
  - Throughput (daily)
  - Latency (minimum / mean over 24 hour interval)
  - Packet Loss (% over 24 hour interval)
- Analysis is done each day to look for potential issues or to see if issues have been resolved
  - More extensive testing occurs to characterize any issues
  - Issues have been disparate but, except for a few cases, have been found to be in the local infrastructures
- JMETC can generate Unclassified Network Characterization reports for any test customer for the ranges of their testing

SYSCON Daily Network Characterization

- SYSCON performs daily network characterization across all JMETC sites:
  - Throughput (nightly)
  - Latency (measured every 15 seconds over 24 hour period)



JMETC LiveCD

Prototype of JMETC LiveCD has been developed for experimentation

- Based on FedoraLiveCD
- Locked down based on USJFCOM JATTL Red Hat 4/5 configuration
- Includes IVT, NUTTCP, Wireshark, etc.
- Tested on USJFCOM JTEN testbed in JATTL
- Used for troubleshooting SDREN issues at Dahlgren
- Can be customized to include additional software and/or configurations

Network Services Provided

- JMETC SYSCON / Connectivity Team
  - New site network checkout and functionality testing
  - JMETC Personnel available to test, monitor, and troubleshoot network connectivity
  - Web-Based Help Desk and Phone Support
  - Assistance with Local Site configuration through Ports & Protocols management
  - Time sync available from each site SDREN Router
- Inter-Site Collaboration
  - VoIP Cisco Call Manager (soft phone download available)
  - Chat Server (XMPP – Jabber)
  - Secure File Transfer Protocol (SFTP) Server
  - Adobe Connect (collaboration suite similar to DCO with desktop, file, whiteboard sharing and chat)

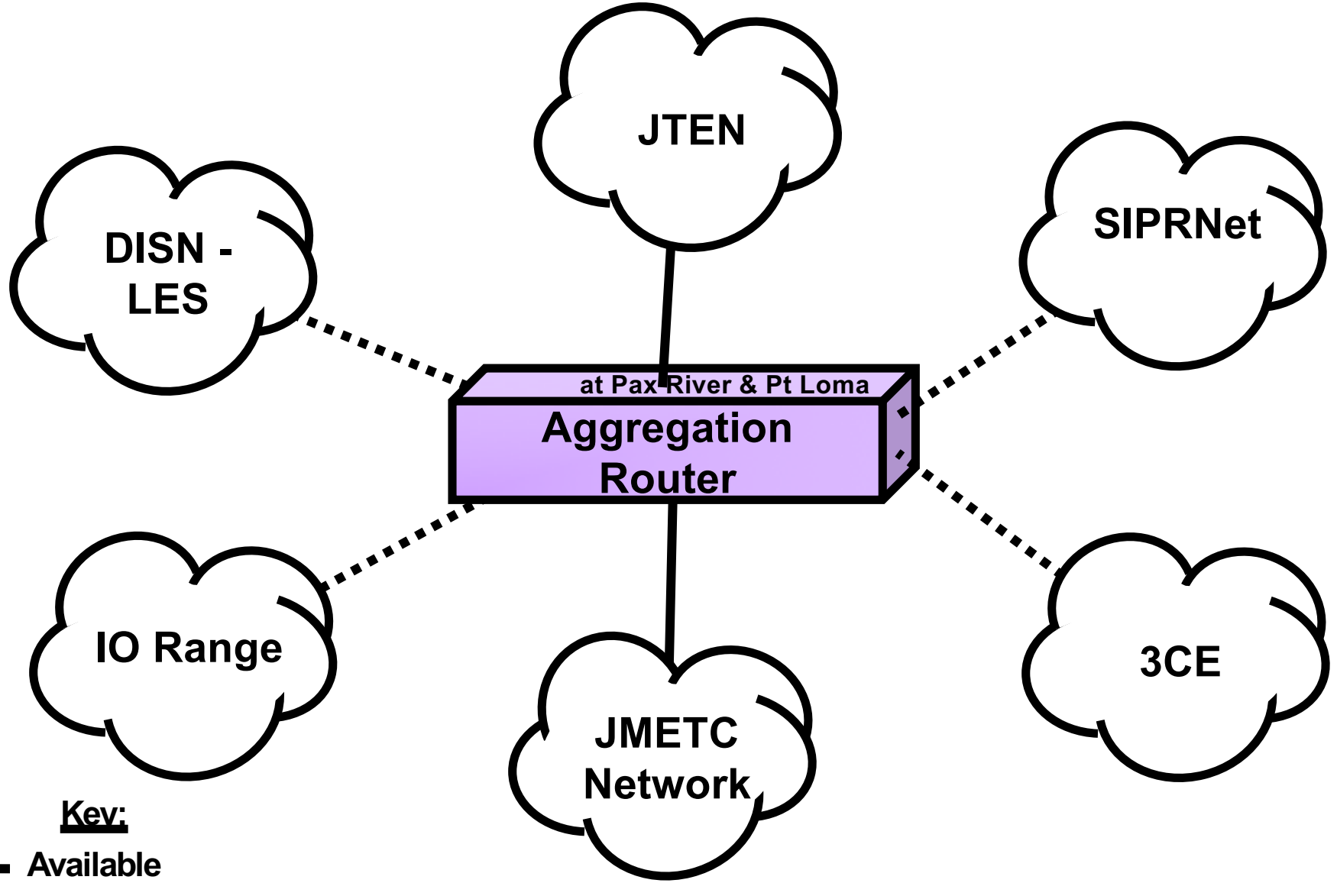
Network Services Provided

- Registered IP Address Space
  - Must use routable IP Addresses
  - Request IP Addresses through the JMETC SYSCON
- JMETC Domain Name Service (DNS)
  - Primary DNS IP Address (S.47.251)
  - Domain: JMETC.SMIL.MIL
- IA Compliance
  - Microsoft WSUS
  - YUM Server (available soon for Fedora and RH)
  - AV updates (McAfee and Symantec)

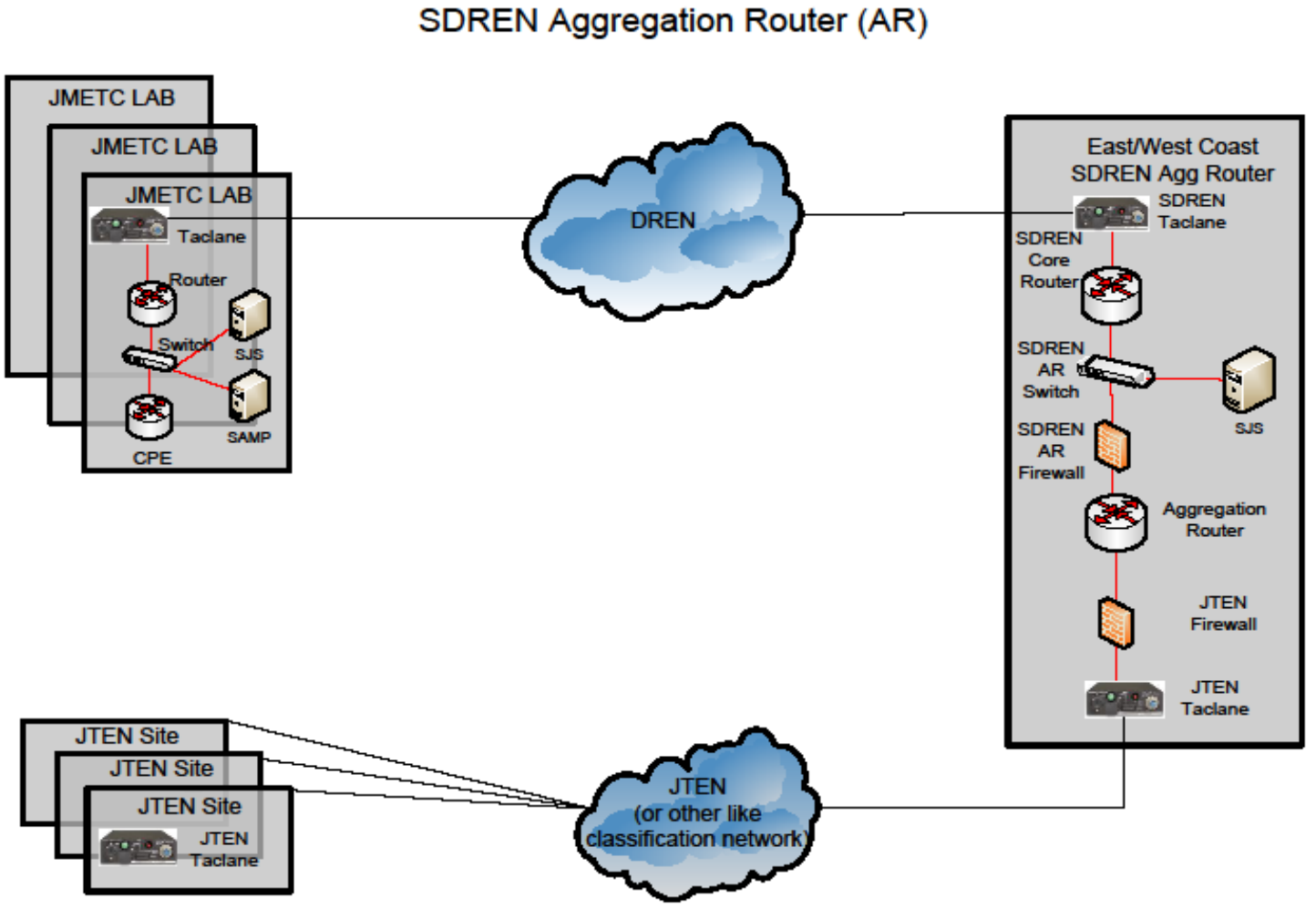
JMETC Connectivity

- The footprint of the JMETC Network is very large but not all-inclusive:
  - Available:
    - Each Services' and Joint distributed RDT&E networks: AF-ICE, ATIN, NAVAIR, JTDL
    - Several Industry partner sites: Boeing, NGC
  - Not natively on JMETC Network Today:
    - Training Facilities
    - Industry Partners distributed RDT&E networks
    - Other government entities outside of the DoD
    - Coalition Partners
- JMETC Connectivity is more than the JMETC Network on SDREN
  - Peering points to Industry Partners
  - Network Aggregation

Network Aggregation
Bridging Networks

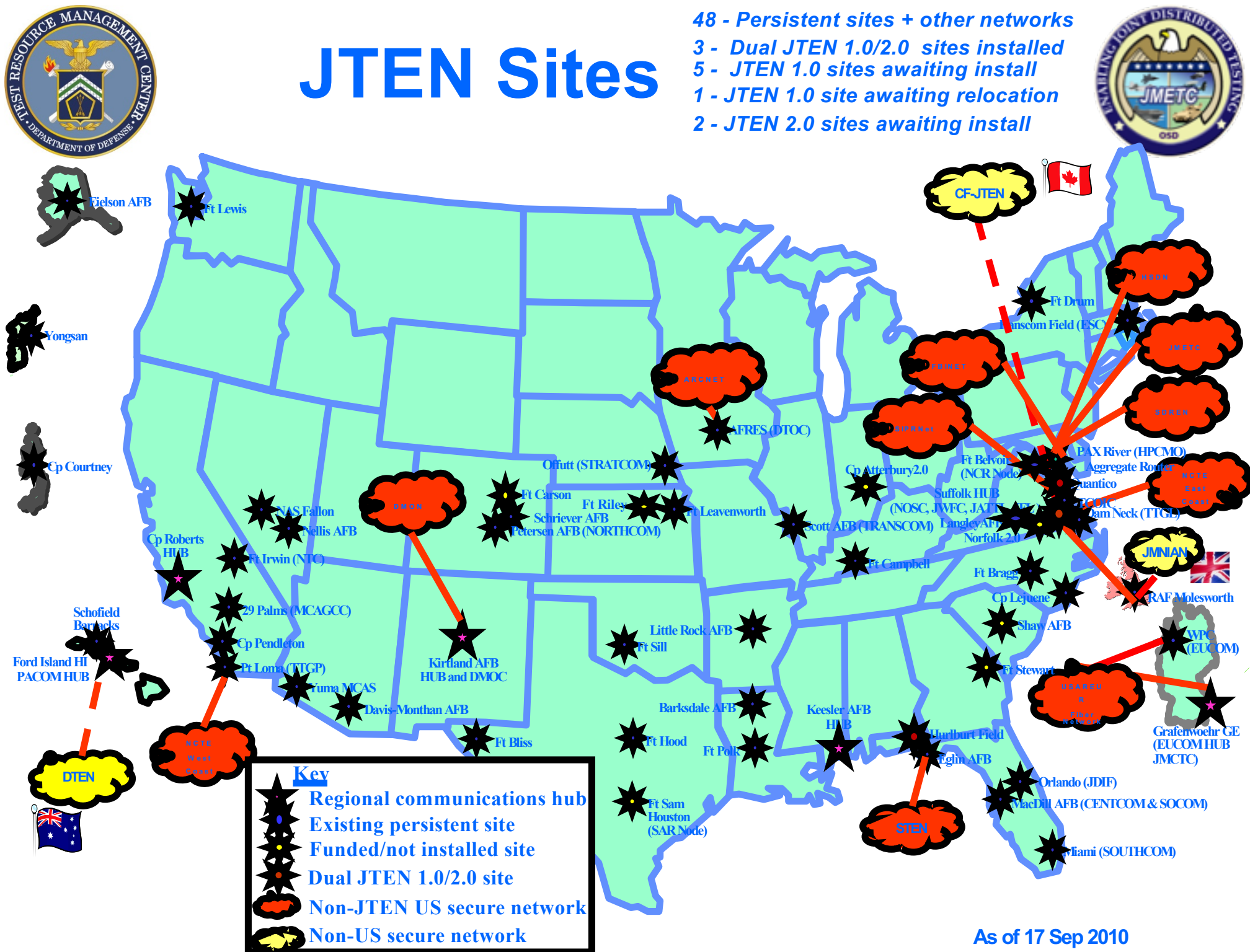


SDREN Aggregation Routers



JTEN Sites

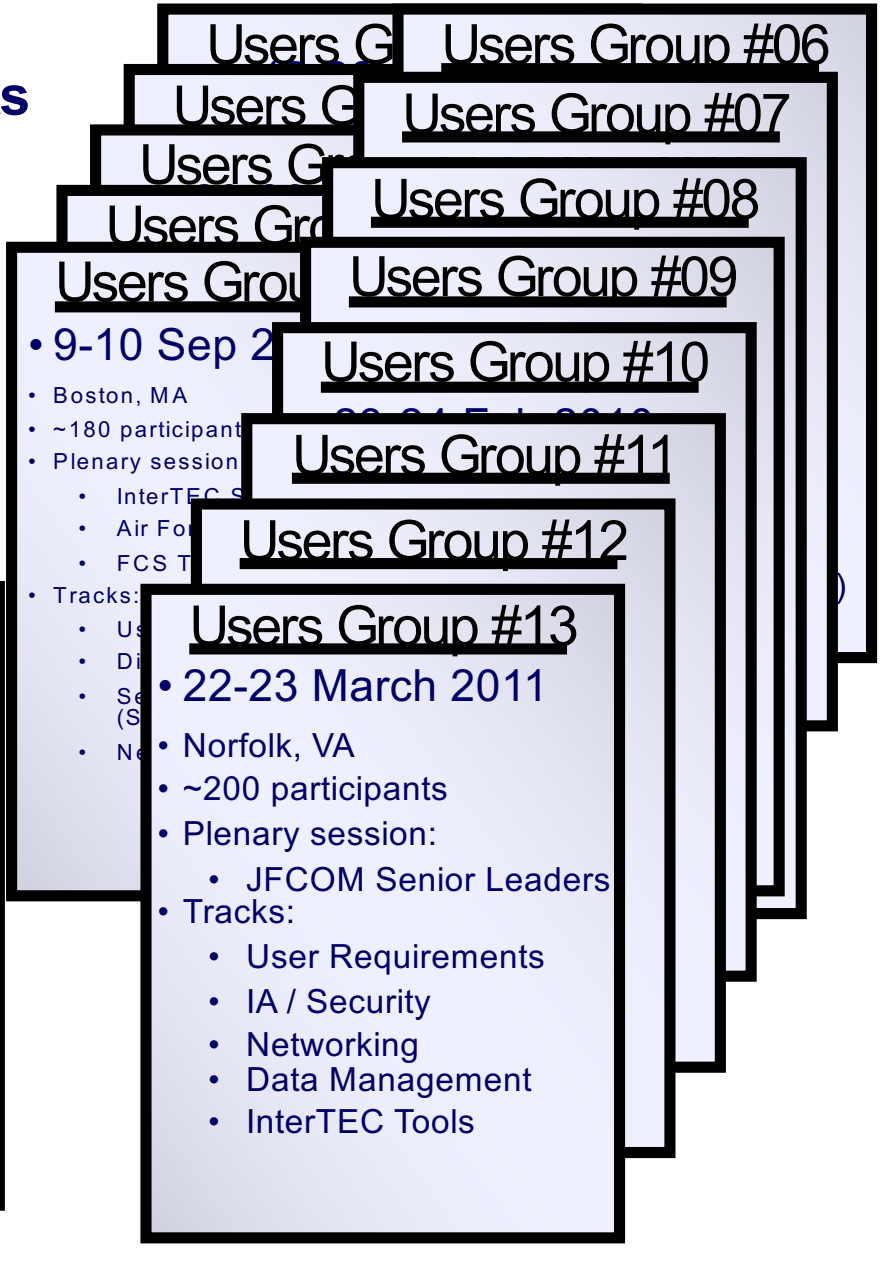
48 - Persistent sites + other networks
3 - Dual JTEN 1.0/2.0 sites installed
5 - JTEN 1.0 sites awaiting install
1 - JTEN 1.0 site awaiting relocation
2 - JTEN 2.0 sites awaiting install



As of 17 Sep 2010

JMETC Users Group Meetings

- **Identify core infrastructure requirements and use cases**
- **Identify, investigate, & resolve issues**
- **Identify opportunities to collaborate**
- **Discuss available solutions, tools, and techniques**
- **Share lessons learned**



Last JMETC Users Group Meeting:

Dec 11-12, 2012
Location: Charleston, SC
Tracks:

- User Requirements
- Networking
- Data Management
- Threat Systems (FOUO)
- Cyberspace T&E (FOUO)

Enhanced Distributed Test Infrastructure

Current Infrastructure Limitations

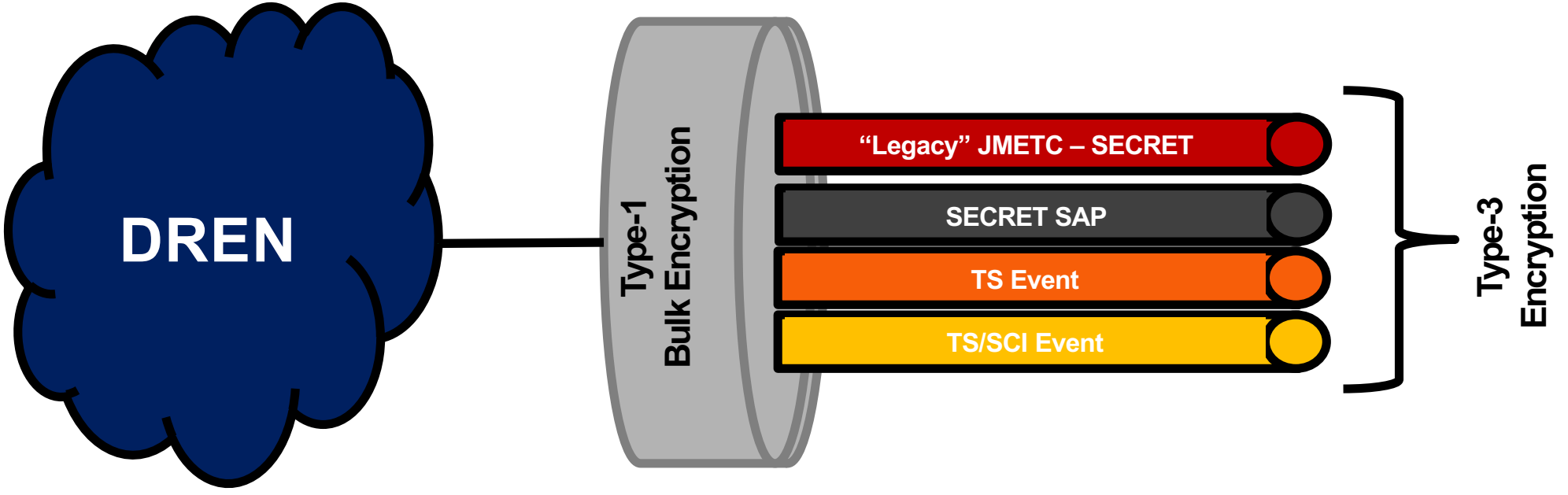
- Classification: Only support SECRET Collateral.
  - Cannot support SECRET SAP/SAR, TS, TS//SCI, TS//SCI/SAP/SAR
- Ability to integrate kinetic and non-kinetic assets
- Fully leverage Regional Service Delivery Points (RSDPs) and National Cyber Range (NCR)
- Coalition: No enterprise solution for Coalition connectivity
  - Current path leverages JTEN “peering”
    - Low priority
    - Infrastructure limitations
- Tactical & Non-routable IPs: Not supported
  - Many tactical systems have hardcoded IPs
  - Many ranges use non-routable IPs locally

JMETC MILS Network (JMN)

- Focus is on supporting ***higher classifications*** and providing ***secure, isolated testbeds*** to meet growing Cyber T&E requirements
  - Accredited by DIA to operate up to TS//SCI (included NSA Red Team assessment)
- Employs Multiple Independent Levels of Security (MILS) architecture
  - Allows for segregation of data streams, events, COI, classifications, etc.
  - Ability to create "sandboxes" for Cyber T&E
  - Capable of supporting multiple simultaneous events at multiple classifications concurrently
- Leverages Defense Research & Engineering Network (DREN) for transport
- Limitations
  - Requires security agreements for each event (valid up to 1yr)
  - Some support services may not be available unless JMETC personnel are "read on"
  - Not feasible to provide dedicated instantiations of some capabilities (e.g., Adobe Connect) for each user environment

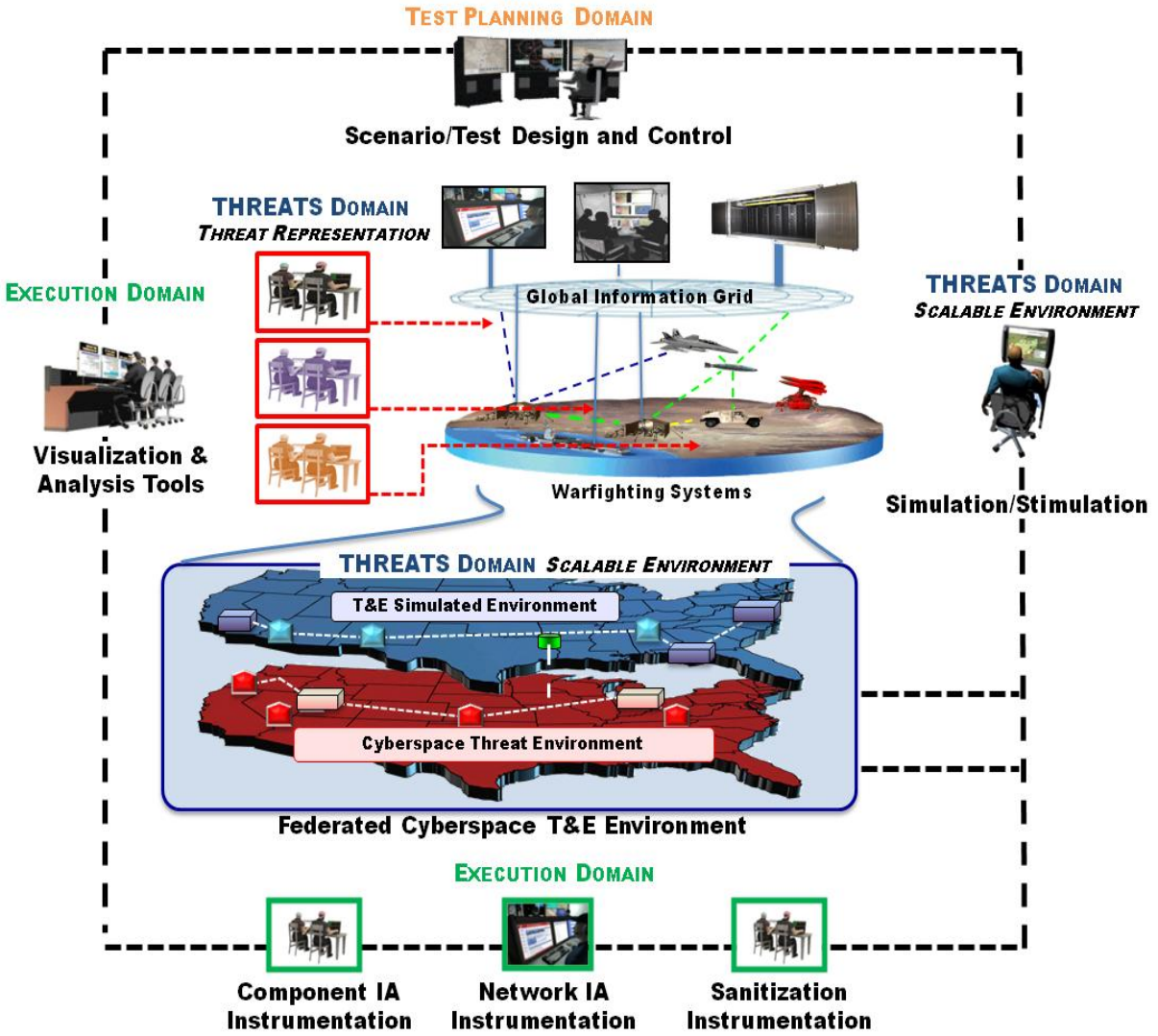
Distributed Test Infrastructure Enhancements: Architecture

- Use unique Type-1 Encryption Key for bulk transport over DREN
- Segregate classification, events and communities thru Type-3 encryption (i.e., “logical ranges”)
- Each site can leverage one or more logical ranges



Cyber T&E Initiatives

Cyberspace T&E Strategy Overview



Four Major Thrusts

1. Cyberspace T&E Process

- Additional activities to test cyberspace during the acquisition process

2. Cyberspace T&E Methodology

- Test approach to adequately assess cyberspace capabilities/limitations

3. Cyberspace T&E Workforce

- T&E training to enable T&E professionals to conduct future cyberspace T&E

4. Cyberspace T&E Infrastructure

- Existing DoD Labs, Ranges, & Networks
- Industry & Academia Accessible
- Common Framework for:
  - Cyberspace Environment Tools
  - Cyberspace Test Instrumentation

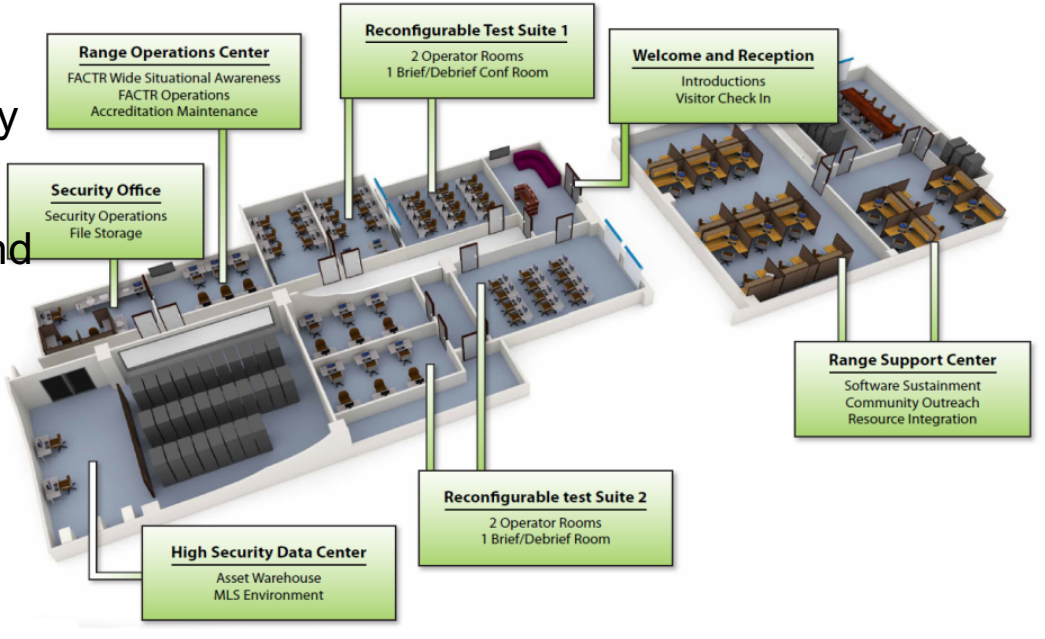
Test & Evaluation that accurately and affordably measures cyberspace effectiveness and vulnerabilities of warfighting systems and DoD information systems, to verify the warfighter's capability to achieve mission success while operating in cyberspace

National Cyber Range (NCR) Orlando, FL

- **Oversight**
  - Transitioned program from the Defense Advanced Research Projects Agency (DARPA) to the TRMC in October ’12
  - TRMC charged with functionalizing the capabilities for use by the Test, Training, and Experimentation communities

- **Goal**
  - Create a secure, self-contained facility that can rapidly emulate the complexity of defense & commercial networks, allowing for cost-effective and timely testing

- **Range Features**
  - Automated range build-out capability
  - Automated range sanitization
  - User friendly environment design and test planning tools
  - Supports multiple concurrent tests events at varying classifications



Regional Service Delivery Points (RSDPs)

- **The Regional SDPs (RSDPs) will:**
  - provide increased ***capacity and scalability*** to create persistent, representative cyber-threat environments
  - provide ***common range services*** (i.e. traffic generation, simulation, instrumentation, visualization, and integrated event management)
  - be ***flexible and adaptable*** to evolving users requirements
  - leverage the latest technology to deliver ***cost and performance efficiencies*** (virtualization, rapid reconstitution)
- **Challenge: Accreditation of MILS architecture**
  - Potential hurdles with sanitization and segregation

Address Capacity & Capability Gaps

The Cyber T&E Support Cell

- **DOT&E, TSMO and TRMC have partnered to help fill gaps in Cyber T&E shortfalls**

- **The Support Cell is focused on:**
  - RSDP Development and Fielding
  - RSDP and NCR IA Accreditations
  - Event Planning
  - Event Execution

Partnership between DOT&E, TSMO and TRMC to develop the next-generation Cyber & Interoperability Distributed Environment

Cyber Range Interoperability Standards (CRIS)

- **TRMC sponsored WG supported by MIT Lincoln Laboratories**
  - Government, Industry and Academia
- **Cyber Ranges have been independently developed**
  - Tools
  - Processes
  - Architectures
  - Underlying Technologies
  - Lexicon
- **Result is stovepipe solutions that are difficult to integrate**
  - Limited scalability
  - Increased cost and schedule
- **Goal: Identify key interoperability gaps and recommend solutions/approaches**
- **Task Status**
  - Lexicon v0.1: incorporating feedback for release in October
  - Cyber Range Process: incorporating feedback with anticipated release in November
- **Next Steps:**
  - Identify Key Interoperability Areas
  - Develop Prioritization Criteria

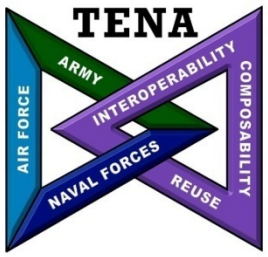
Enable Interoperability through Standardization

Additional TRMC Investments

- **T&E/S&T Cyber Test Technology (CTT) Sponsored Efforts**
  - Expand upon current automated sanitization capabilities for Cyber environments
  - Develop models for accurate, large scale cyber threat simulation at all layers of the OSI model
  - Develop automated threat portrayal capability
  - Status
    - Award made to Georgia Tech Research Institute in March 2013 to develop ACTR with anticipated completion in FY16
    - Award made to Lockheed Martin in June 2013 to develop enterprise sanitization capability with anticipated completion in FY16
    - Award made to Scalable Network Technologies for development of high fidelity, large scale network emulation in FY14

- **Central T&E Investment Program (CTEIP) Sponsored Efforts**
  - Develop enhanced defensive Cyber instrumentation
  - Develop enhanced LVC representations of large scale operational environments
  - Status
    - In early development with SPAWAR to develop Cyber T&E specific instrumentation and high fidelity, large scale, operational representative environments with anticipated completion in FY17-18

- **JMETC FY15 Tool Focus Areas**
  - Cyber T&E planning, execution and analysis tools
    - Environment Generation
    - Visualization
    - Non-intrusive Instrumentation
    - Real-time analysis
    - Automation
    - More…



"Current" Path Forward

- **JMETC continues using the SDREN to support secret-level requirements, adjusting as needed to meet customer test requirements**
- **JMETC is building JMN to address higher classifications and provide a secure testbed for Cyber testing**
- **JMETC and JIOR leverage each other's capabilities**
  - For Cyber testing, see (mission) effects on the JMETC; leverage JIOR, TSMO, and others for threats
  - JMETC provides JMN for TS/SAP/SAR and coalition testing

JMETC is making investments to address shortfalls in the Cyber T&E process, methodology, workforce & infrastructure

Summary of JMETC

- Supports the full spectrum of Joint testing, supporting many customers in many different Joint mission threads
- Being built based on customer requirements
  - JMETC support can be tailored to customer needs
- Partnering with Service activities and leveraging existing capabilities
- Coordinating with JS to bridge test and training capabilities
- Users Group provides an open forum to present emerging requirements as well as new technologies & capabilities

Concluding Remarks

Summary of What We Have

An Architecture for Ranges, Facilities, and Simulations to Interoperate, to be Reused, to be Composed into greater capabilities

- A Working Implementation of the Architecture
  - TENA Middleware currently works on Windows, Linux, and Sun
- A Process to Develop and Expand the Architecture
  - AMT Meetings and JMETC User Groups
- A Technical Strategy to Deploy the Architecture
  - Gateways provide interim solutions as TENA interfaces
- A Definition of Compliancy
  - Levels of compliancy to enhance communication among systems engineers and investment decision makers
- A Persistent Network to permanently connect test sites
  - JMETC network enabled with TENA allows new tests to be performed with much less lead time and expense compared to the past

Summary

- **TENA offers significant benefits to the range community**
  - Common data standards, interfaces, communication software, and tools to improve interoperability, reuse, and long-term sustainability of range assets for reduced O&M
- **TENA is the CTEIP architecture for future instrumentation, the JNTC architecture for Live integration, and an enabling technology for JMETC**
- **JMETC provides inter-range connectivity and supports the full spectrum of Joint testing, supporting many customers in many different Joint mission threads**
- **TENA and JMETC are:**
  - Being built and evolved based on customer requirements
  - Partnering with Service activities and leveraging existing capabilities
  - Coordinating with JNTC to bridge test and training capabilities
  - Provide a forum for users to develop and expand the architecture
    - **Next TENA AMT-52 Fall 2016**
    - **Next JMETC User Group Fall 2016**

Important Contact Information

- **TENA Website: http://www.tena-sda.org**
  - Download TENA Middleware
  - Submit Helpdesk Case (http://www.tena-sda.org/helpdesk)
    - Use for all questions about the Middleware

- **JMETC Program Office Contact:**
  - E-mail: **jmetc-feedback@jmetc.org**
  - Telephone: (571) 372-2699
  - JMETC Website: **http://www.jmetc.org** – under construction

- **TENA Feedback: feedback@tena-sda.org**
  - Provide technical feedback on TENA Architecture or Middleware
  - Ask technical questions regarding the TENA architecture or project
  - Provide responses to AMT action items
  - Request TENA training